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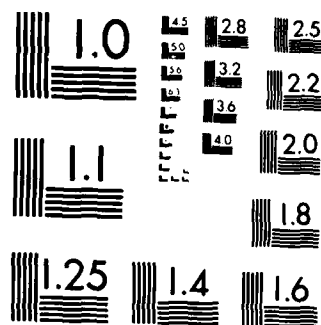
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Design issues in video disc map display

Judy M. Olson

October 1984

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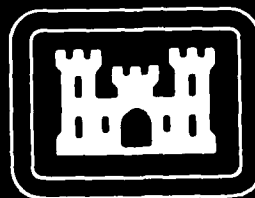
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Prepared for

U.S. ARMY CORPS OF ENGINEERS
ENGINEER TOPOGRAPHIC LABORATORIES
FORT BELVOIR, VIRGINIA 22060-5546

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20. ABSTRACT continued.

eliminate seams in images and legends that fit to monitor width. Existing maps could be modified to preserve readability of small symbolism. The disc itself could be examined for possible areas of improvement for holding map images. Areas for experimentation include user abilities to deal with the equivalent of small map portions, the overlap problem and the problem of designing maps that portray the same area at different scales and allow the user to recognize that they are all of the same area.

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SUMMARY

Video disc display of maps is a very recent phenomenon. Design issues with this form of display include those dealing with the map itself, those dealing with the disc, and those dealing with the hardware and software system. If topographic maps are designed especially for video disc, they should be designed such that the desired amount of earth area will fall within about a 3.75 x 5 cm map size, which is the area of a graphic image at normal reading distance that can be resolved on a standard television monitor. Other maps, such as simple base maps and relief maps, may be captured in larger sections. Video maps should be "proofed" in video form, i.e., examined using a video camera. Potential design features would include sheet overlap such that there would be no seams in images, legends that fit the width of monitors, and so on. If existing maps are captured on discs, there are also numerous design considerations. They include modification of the existing map so very small symbolism is brought to readable form, and design of the disc itself such that positive features of disc technology are utilized while the pitfalls are avoided (such as attempting to capture too large an area). Much of the design development work will depend upon pragmatic procedures for improving design. Items warranting careful experimental work include user abilities to deal with the equivalent of small map portions, the overlap problem, and the matter of how maps at different scales should be designed to be recognizable as portraying the same area at a different scale. A working list of existing map discs is included in an appendix.

ACKNOWLEDGMENTS

This study involved site visits to the Engineer Topographic Laboratories (ETL), Fort Belvoir, VA; Water Resources Support Center (WRSC), Fort Belvoir, VA; Army Communications Technology Office (ACTO), Fort Eustis, VA; Automated Command Training Division, Fort Leavenworth, KS; Perceptronics, Inc., Rosslyn, VA; Geoview, Inc., Rosslyn, VA; Online, Inc., Germantown, MD; Decisions and Designs, Inc. (DDI), McLean, VA; RCA Automated Systems, Burlington, MA; the Architecture Machine Group laboratory at Massachusetts Institute of Technology (MIT), Cambridge, MA; New Media Graphics, Burlington, MA; and the MITRE Corp., Bedford, MA. In addition, numerous phone calls were made to other organizations working with video discs. The information, ideas, and demonstrations provided by the personnel of these agencies and companies have made a good portion of this report possible. Because of the intertwining of ideas from one source to another, it has been impossible to credit individuals or even firms with the specific ideas in this report. The fact that many of them did not originate with the author, however, is readily acknowledged.

The assistance of Gustave Rylander is also acknowledged; Gus did the library work and prepared the annotated bibliography in Appendix A. Finally, the cooperation and helpfulness of the staff at ETL, especially Daniel Costanzo, Doug Caldwell, and Richard Clark, have been invaluable in completing this study.

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DESIGN ISSUES IN
VIDEO DISC MAP DISPLAY

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I. INTRODUCTION

Recreancy of Video Discs as a Map Display Medium

Video discs are one of the newest media for the storage and display of visual images. The optical disc, with its random access capabilities as well as freeze-frame and long-life characteristics, has begun to draw attention from a number of people involved in map research, map making, and map use. At this stage of infancy in the use of video discs for map display, there are numerous articles in the literature on the technology of video discs, but there are probably fewer than 100 discs on which map images have been recorded, little accessible literature relating specifically to video disc map display, and a relative handful of individuals (most in private firms or military organizations) who are knowledgeable about the various mapping problems involved in video disc map display.

Purpose of this Project

The purpose of this project is to explore design questions in the context of video discs. The project did not involve rigorous experimental work. Rather it took a broad look at the experiences both of those who have been involved with the capture of maps on video disc and those involved with the use of the resulting imagery, and it used various methods to derive at least rough answers to questions arising. In sorting out some of the broader issues and conceptual notions, this report will relate some already-known concepts of map design to the issue of maps on video discs, but it will also point out some rather different issues involved and will suggest other work to be done in the future.

The ultimate reason for doing this type of investigation is to "evaluate" the usefulness of video discs for map display, or, more accurately, to contribute to that goal. There are two very different ways of approaching evaluation: one can ask "are they useful for this particular set of purposes?" or one can ask "for what purposes are video disc map displays useful?" This report is not a definitive answer to either question, but the viewpoint taken leans distinctly toward the latter.

Organization of this Report

This brief introduction to the study will be followed by Sections II through V and Appendices A through E which are summarized below.

Section II, Video Disc Technology and Vocabulary, will give an overview of background material so the technology under discussion and its associated vocabulary will be clear.

Section III, Questions of Design, will sort out various components of "map design" (which now include software and system design) as related to video discs. It will reflect not only some of the experiences and ideas of those working in the area, but will also consider ideas that can be adapted from conventional map design to the designing of maps for video discs.

Section IV, Further Design Work in Video Disc Mapping, will distinguish between two major approaches to map design improvement, the pragmatic and the experimental, and will focus in on selected key issues for further work.

Section V, The Future of the Video Disc for Map Display, will touch on some items that are peripheral but nonetheless relevant to a study of design issues in video disc map display.

Appendix A, Annotated Bibliography, is a selection of materials that are of potential interest to anyone working with video discs as a medium for map storage and display.

Appendix B, Map Video Discs: A Listing, briefly describes video discs already in existence or in progress that contain map imagery.

Appendix C, The Relationship Between Map Area Per Frame and Map Legibility, is an essay developed during the course of this project that supplements the material in Section III.

Appendix D, Observations About Type on Video Discs, summarizes some observations derived from examination of type specimens under a video camera.

Appendix E, Illustrations, is a supplement showing such items as the equipment used by ETL in its work with discs and selected images from a disc.

II. VIDEO DISC TECHNOLOGY AND VOCABULARY

Video disc technology has been around for several years now, and one can find numerous articles, chapters, and books on it in the engineering, computer science, and popular computer literature (see annotated bibliography in Appendix A). Yet it is sufficiently new that even the spelling of the term (video disc, videodisk, videodisc, video disk; see Unattributed 1980a, Rothchild 1983, Daynes 1982, and Clemens 1982, respectively) varies from one source to another, and the vocabulary and even the basic characteristics of video discs are not widely known in cartography. In the whole investigation, we encountered only one set of topographic maps (DMA, late 1970s, Fulda Gap area), one overview/location map (Perceptronics), and one set of base maps (by Donnelley, on an MIT disc) that had been designed specifically for video display (non-broadcast). Hence, it seems appropriate to cover some basic information about video discs before attempting to discuss design issues. (Much of the vocabulary here comes from Daynes 1982.)

Major Terminology

The term video refers to a television image. The standard home television set is equipped with a receiver, which is capable of picking up a signal transmitted through the air, as well as a monitor, which is the device on which the image is displayed.

A set of images can also be stored on a variety of media to be played back locally rather than be picked up by the receiver. Video tape is a common medium, for example, for home use and can be written on as well as played back locally. In ordinary home use, the signal recorded on a video tape is a broadcast one, but a video camera can also be used to directly produce a tape recorded image. A video camera can be attached directly to a monitor as well, such that one can view the image at the same time the camera is picking it up (i.e., one can view it in "real time").

A video disc is an alternative medium to video tape. It resembles (visually) a long-playing phonograph record, and it has a series of pits varying in length and spacing in a circular or spiral pattern. There have been at least three distinct types of discs that can be distinguished (Clemens 1982). They are different from one another in the way in which they are "read." One was a pressure pickup disc that was very short-lived. A second is a capacitance disc from which a stylus picks up electrical information. The stylus is in contact with the disc in grooved capacitance systems; it is not in direct contact in the grooveless capacitance systems (Marsh 1982). The third type is the optical video disc which uses a laser to write on and read the disc (though the writing and reading are normally performed in very

different environments). Usually it is the reflected laser beam that is used to read the laser disc but in some cases it is the transmitted beam. The optical video disc also comes in more than one variety. The consumer-formatted disc has a spiral track and uniform density of information. It plays for one hour per side and is played at a constant linear velocity. The industrially-formatted disc has 54,000 frames per side in concentric tracks (one frame per track) and is played at a constant angular velocity. At 1800 rpm, it plays for 30 minutes per side.

It is only the third type, the optical video disc, that is of direct concern in this investigation and only the industrially-formatted variety. The physical form of the optical video disc includes a protective transparent plastic over the information layers, and since a laser beam (rather than mechanical stylus) is used to read it, the optical disc does not wear out with use. Ten years seems to be the prevailing (and conservative) estimate for longevity (compared to two years for a magnetic tape). Furthermore, one can freeze frames, i.e. stop on a particular image and display it indefinitely, without damaging the disc. And the industrially-formatted optical disc allows random access to frames; one can view the frames in any sequence and skip from any frame to any other one of the 54,000 frames on that side of the disc in a few seconds at most. When the industrial disc player is attached to a computer, this random access capability can be exploited for access to the disc in a variety of ways.

The information on an optical video disc is not in digital form, but rather in standard television form. Using appropriate hardware and software, the signal can be converted into digital information, a technique that is used by at least two companies doing development work with maps on video discs (DDI, MITRE). The information physically on the disc retains its original form, and the digitized data are stored only temporarily in computer memory unless recorded on some other permanent medium.

There is an alternative type of disc, however, that is also written and read with a laser beam and its information is in digital form. It is called an optical digital disc rather than optical video disc. It is capable of carrying literally billions of bits of information, and this digital information, assuming it is an encoding of a visual display, would have to be processed to be displayed on a video monitor. While not at the center of attention in this study, digital discs are of great interest in the area of map storage and display.

Yet another type of disc, actually only another variation on the video disc, is what is referred to as a hybrid disc. This type stores both video and digital information. And the "floptical disc" is a recent variation that is a physically flexible, rather than rigid, disc.

Video Disc Players and Means of Access

Having established that it is the industrially-formatted optical video disc that is of central interest here, there are some additional background matters of concern. Use of a video disc requires certain equipment, including at the very least a video disc player and a accompanying monitor. (For a more complete list for video disc map display, see Costanzo 1984a.) The industrial player (for industrially-formatted discs) has a set of controls that allows forward or reverse play-through, freeze frame, forward or reverse one frame at a time, and selection of frame by number. The frame numbers can be fed to the player by a computer, and this is, in fact, the most important means of access. In this case, an access data base or access function will usually be available as well as the software that allows one to use it. For example, let us assume we have a set of map segments on a disc that gives topographic map coverage of Lower Michigan. If one wants to look at a specific area, such as the town of Owosso, one is not likely to have memorized the frame number. Searching the disc by playing it through until Owosso appears would be time-consuming and, unless the topographic maps had been panned very slowly (high percentage overlap), would be very uncomfortable viewing. But if the software will accept a request to see Owosso, and if there is a data base that matches the frame number with that name, one can "find" the frame quickly and easily. Likewise, if the software will accept a latitude and longitude coordinate and can determine the frame number from that, one has a means of accessing the disc.

With appropriate equipment and software, one can also overlay images created from digital files of information onto images being displayed from a disc. A digitized symbol, for example, could be displayed on the screen to highlight the locations of hospitals in

Disc Production

Having covered various types of discs and certain features of the optical video disc, especially in a computer environment, that make it of special interest, there is one other matter that needs to be covered in this introduction to the technology and vocabulary of video discs. This is the matter of developing and producing the discs and the attendant roles served by varying individuals or organizations.

First, it must be stated clearly that, unlike home videotapes and the relatively rare DRAW (direct-read-after-write) discs, the common video disc is made by a piece of equipment very different from that with which it is read. The actual production of the disc is a highly specialized and expensive process, and is, in fact, one of the most serious drawbacks to the technology. But let us begin with the very conception of a specific video disc and look at the various stages and the terms used to specify them. To say that John Doe, or even Company

multiplication) as a regular monitor without pixel enlargement.

(4) Reversible zoom sequences. A minor but interesting (and bothersome) characteristic of current zoom software, which finds the frame next higher or lower in the zoom sequence, is that one can go away from the earth's surface such that the original area is kept within the bounds of the larger area, but one cannot normally zoom back to the original area. Even the outward zoom is awkward under present conditions (capturing of conventional maps) because the location of the first area within the second and so on is unpredictable for the viewer. The problem might be lessened by a temporary superimposed rectangle delineating the previous frame area. Not being able to come back again, however, is even more bothersome in that it means one will have to search once the original zoom level is again reached. Reversible zoom would be a useful feature.

(5) The hardware/software/disc generality. One characteristic that was very noticeable about the configurations of hardware/software/discs was that there was little interchangeability. We did not penetrate the software deeply enough to make any sweeping statements about its generality, nor was hardware a central concern for us. On the other hand, there was no ready evidence of sufficient development at this stage that would allow "plugging in" of a minimum number of parameters so that a new disc could be operated with the same software. This is surely too early a stage to expect anything requiring that much coordination of disc arrangement, software, and hardware, but it will be a prerequisite to extensive map disc usage.

Design Utilizing Existing Maps

The previous material in this section has been based primarily on the notion of maps specifically designed for discs. This is diametrically opposed to a predominant view of the video disc as an immediate medium for capturing currently-existing maps, thus making use of computer power on a more immediate time-scale than possible with digital mapping. Any current evaluation would have to question the viability of the notion of tailored design, since redesign of maps may not be viable. Adapting current maps for capture on video discs is undoubtedly much faster than either redesign or digitization, and these already-available maps are the material actually being captured on disc currently. In the following paragraphs, then, it is simply assumed that current maps will be used. Rather than reiterating all design issues given that assumption, only the specific ideas about improvement of such discs will be included here. They are possible actions based primarily on viewing the ETL disc and the sample of others seen at site visits.

- (1) Avoid the larger map segments that are blurry.

feature, its name. With the development of computerized place-name files this is a system feature ripe for development.

(2) Overlay capabilities. Overlay capability is commonly included in the systems currently being developed. They are such an integral part of the use of the disc that there is little question of the usefulness. The overlay digital image is sufficiently different from the disc image that it is useful for highlighting, as well as just adding items. The design of the overlay symbolism is a topic of interest in its own right. While this study dealt more with the original map design, several variations in overlay were either observed, mentioned in conversation, or came to mind, and these include:

(a) pointing to a menu of symbols and "placing" the chosen symbol on the screen;

(b) indicating a location by giving UTM (or other) coordinates and seeing an appropriate symbol on the screen;

(c) asking for an item, such as the nearest feature of a certain class, and seeing it highlighted on the map;

(d) moving a cursor to a map location, giving a command (e.g., attack) and having a symbol appear as a record of the command;

(e) blinking a symbol to cause highlight.

(3) The use of color separations. This is an interesting variation on map capture that involves camera capture of the registered overlays that make up the conventional map. A black-and-white frame is recorded for each overlay. As each frame for a given map area is "grabbed," it is instantly digitized and stored. The user can then choose which features will be included and the order in which they will be plotted and the color in which each will be encoded. The image is then digitally generated and displayed on the screen. In the case of (at least) the DDI system, one can do a hardware zoom (pixel multiplication) and then smoothly pan. As one pans in a given direction the computer grabs and digitizes the neighboring frame so that smooth panning continues right into that part of the map.

The smooth panning in such a system is an advantage, and selection of features and designation of colors for encoding are interesting capabilities. The extra frames taken up by overlays, the larger amount of computer power needed, and the relatively limited amount of displayable information available under pixel multiplication are among the disadvantages. The lack of consistency in the number of separations and their content is also a problem (information from DDI). Specially designed maps could potentially be very helpful in a system of this sort, and the use of high-resolution monitors would allow approximately the same zoom resolution (with one step, 2X pixel

Shooting parameters (light level, camera settings, etc.)
Any other brief information characterizing the sequence

Such slates can be typed on an ordinary typewriter, so they require no extraordinary efforts.

There should also be a few slates at the beginning giving a disc title, the date, client, pre-producer, pre-masterer, masterer, and contact address and phone number as well.

(6) The capture of "critical areas." This is a part of the general issue of "meaningful areas" being captured on a disc and should be but a minor issue if other aspects of disc and map design are well-done. On discs with small amounts of overlap, however, it is an especially noticeable problem that a major point of interest is to the far left on one image, the far right on another and can never be brought to the center of the screen so one can see it in context. Assuming that sufficient earth area and symbolism falls within the map capture area to make individual areas spatially meaningful, and assuming 75% overlap of images (vertically and horizontally), the worst location for a major point of interest would be at the very middle point of any of the sixteen rectangles within a frame space divided by a 4 x 4 grid. That point would never be closer than a quarter of the screen diagonal from the center of the image. If certain points are of sufficient interest to put in the center of an image, supplementary frames so located should be included on the disc. A standard transparent grid of the overlapping frame areas that is coordinated with camera movement parameters can be put over any map to see if critical features fall at the centers of the open areas.

Design of the System

Some aspects of system design are too far afield from map design to be covered here. For example, touch-screens are often used as part of the hardware system and this is a part of design. But there are various touch-screen technologies, one of them sufficiently sensitive that we heard a story of a system demonstration during which a wayward fly landed on the screen and unexpectedly signaled the image to change. The hardware designs that result in such problems are not covered here; rather a few general observations are made on items particularly noticeable to a cartographer.

(1) The access mechanisms. These, together with good disc design, are extremely critical. UTM coordinates can be used with some discs to access frames; and joysticks, trackballs, adjacent keys on a keyboard, and touch panels have been tried as mechanisms for moving to neighboring frames. In general, access by coordinates seems to be limited at this stage. Even more noticeable, none of the systems we saw used the sort of information one generally has first about a

small piece of earth. To do that requires the very same number of images at each zoom level. No current disc with extensive area coverage has comparable numbers of frames at various zoom levels because there would be a tremendous number of frames required, and, especially at the blurry levels, such coverage is wasteful.

(4) Sequencing of frames. Maps may be on the disc in sequential order from left to right, right to left, top to bottom, bottom to top, or in any of four diagonal sequences and this (together with degree of overlap) is important to how closely one can simulate "panning." It is software that searches for the neighboring scene, but it is positioning on the disc that determines how quickly a neighboring image will show up on the monitor. Sequential frames appear without visible blanking on the monitor; frames far apart are separated by a noticeable gap. While it is nice to be able to pan uninterrupted in any direction, the number of frames required is multiplied by the number of directions of movement. Images recorded only left to right requires n images for a given area; to move smoothly right to left as well requires $2n$ images; and to be able to move up-down, down-up, diagonally up-right, diagonally down-left, diagonally up-left, and diagonally down-right as well requires $8n$ images. Combined with 75% overlap and an image size for clear capture of area results in extremely large numbers of frames.

There is no clear indication of what choice should be made in this matter, but those involved in experimenting with movement in several directions are going back to limited numbers of directions. Perceptronics reports that the diagonals, in particular, were of little interest to users. It seems, too, that other video disc issues are of far more urgent concern. It does seem reasonable that one should be, above all, consistent (presumably left-to-right or alternately left-to-right and right-to-left by rows), and perhaps (all else being equal) one should put in additional sequences only if sufficient disc space is left to do so.

(5) The matter of slates. "Slates" are transitional images with descriptive information about what appears next on the disc. These slates are not normally read when one is using a computer to access the images, but they can make a disc far more "self-contained" for use with a player only, and they could be very helpful to the study of map design issues in connection with video discs. Current discs are extremely inefficient for even the most general observations about map design because there is often no easily accessible information on what has been recorded on the disc. At this stage in map disc development, a simple slate stating the following information should appear before each sequence on a disc:

- Map sheet and series
- Size (width) of map area being captured
- Size (width) of earth area being captured
- Amount of overlap
- Direction of sequence

(1) The size of image to be captured. If maps are designed specifically for video discs according to a chosen map capture size, this decision is in one sense obviated for the disc designer and transferred to the map designer. In reality, the two would have to make the decision together. In filming conventional maps, it is common to film at various zoom levels on one map, capturing various amounts of map (and earth) area. The problem with this is that legibility deteriorates quickly as the map capture size increases. At the other end, it is fortunate that there is no need to zoom in any closer than enough to achieve clear legibility, since smaller areas of the map would take up huge amounts of disc space (for example, 1-cm widths with 75% overlap would take in the vicinity of 10,000 frames per topo sheet if filmed in one direction only). Some degree of zooming seems justified in filming conventional maps, but the discomfort of viewing blurry images (and the possibilities of misinterpreting or not seeing very small symbols) needs to be recognized.

(2) The amount of overlap. Ideally, one would wish to be able to pan smoothly over the region, but with the high degree of overlap required, the number of frames (amount of disc "real estate") becomes excessive. At the other end of the scale, zero overlap means that many names and features would show up only in parts and never as wholes, making mental synthesis extremely difficult at best. What is surprising is the amount of overlap that it takes to allow recognition of direction of movement across a map, assuming no other cues than the image on the screen (the person controlling direction of movement, say, by moving a joystick up, down, left, or right, will have a motor cue; the onlookers will not). With 67% overlap, direction is not recognizable; 75% overlap seems to be sufficient (information from Perceptronics). Whether size of area captured (hence number of features) or other variables influence the overlap necessary does not seem to be known at this time.

Consistency of overlap is a minimum criterion to be applied. If a user knows that overlap is always 50% and uses some other cue to direction of movement (normally the actual operation of the movement mechanism), then the part of the image that is new will be recognized. But the matter requires noticeable mental effort, and the problem of viewing as an onlooker is not solved. A better criterion is to use at least the minimum overlap required to recognize direction of movement with no cues other than the image itself, since it seems quite conceivable that more than one person would be viewing the monitor at one time.

(3) Zoom relationships. This is a tough issue and would be even if maps were specially designed in the fashion indicated and effectively coordinated visually from one scale to another. The problem is that, ideally, if one wants to "step away," looking at larger and larger earth areas, one would want the first (small) piece of earth area to remain in the center of the monitor, and if one steps in again, one would want to return to the same original image of the

scale but from one scale to another. This would accommodate further experimentations with systems based on the separations (see Design of the System below).

(10) Probably the most difficult of all, the maps at different scales need to be closely coordinated so that any "zooming" toward or away from the earth by going from one scale map to another is visually recognized as "zooming". Theoretically, this would require both graphic cues to scale changes (if moving away, one should sense that from the look of the images) and closely coordinated graphic representation at the various scales so that the same features are recognizable as being the same features. This will be difficult at best when one is designing under identical minimum size constraints regardless of map scale, but it is worth trying nonetheless. While the constraints of including graphic cues to scale change and coordinating the looks of features may seem to be mutually exclusive, the design of conventional maps of all different scales for the same general viewing distance puts cartographers under very analogous constraints. Hence, it may well be possible to keep video disc maps comprehensible as well.

(11) Alternative means of generating these maps is another issue that invites some contemplation. With turnkey computer systems now being used in generating conventional maps, there may be ways of utilizing them for generating special graphics. Let us assume we have a system that can scan a conventional color map, has an edit station to correct features, has files of specially designed symbols and type styles that can be substituted for conventional ones, and can produce separations and printing plates. One could quickly redesign a map modifying symbolism, substituting typestyles, and correcting outdated information. By looking at map capture areas on the screen of the edit station, one may have a somewhat realistic image of the outcome, and if digital images can be transformed into a video signal directly, perhaps the steps of creating the redesigned physical map and filming it with a camera could even be eliminated.

Design of the Disc

The "design of the disc," in the context of map display, refers to the physical arrangement of images on the disc, degree of overlap, and so on. The design of the disc needs to be coordinated with the map design process and with the design of the hardware and software system in which the disc will be embedded.

Disc design is extremely important to the useability of a disc, and it was apparent in viewing various discs that the people involved with disc design are acquiring considerable knowledge from their experiences (see, for example, Johnston and others 1983, Levin 1984). Disc design is, it seems, more conducive to standardization at this time than is map design for video discs. Some of the key disc design decisions include:

than the color itself that caused the problem. At any rate, it seemed clear enough that colors were not equally legible and, as with conventional maps, their choice will have to be made with care. Any potential choices should at least be checked with a video camera and monitor.

There was another observation concerning color that is important as well. Because small map areas are being captured on a video disc frame, moire patterns (the plaids that result from overlapping screens) and even the individual dot screens tend to be visible on the video disc image. Avoidance of overlapping screens may be desirable for video disc maps, and screens should be fine.

(7) The notion of "meaningful area" will have to be considered in tailoring maps to the needs of users. The choice of how wide an earth area should fit in the chosen map capture area is extremely critical. Weapon ranges, vehicle speeds, and speed of troop movement are some military determinants of how much area is needed on an image to be meaningful. Working with missiles with a 3000 m range imposes a very different requirement than artillery with a 20-30 km range. Recognizable areas or features are a more general requirement (a user can easily recognize the state of North Carolina, for example, but not a random 50-mile wide piece in that state unless at least two familiar features appear within it).

The concept of meaningful area also comes up with respect to such items as legends, text material, and certain key areas within a region. A legend should be designed such that information fits within the map capture width. Text material, if included on a map disc should also fit with the capture width and it should be "paged" from one frame to another (no overlap) since overlap simply slows a reader down. Key items on the map, such as points of central interest, need to be at or close to the center of at least one image. This is primarily a disc design problem and will come up again in the subsection on disc design. It needs to be considered in the design of the map as well since it could be a factor in the placement of lettering and so on. (A simple piece of film with a transparent window the size of the map capture area could be a useful item for the map designer).

(8) Map coverage of an area to be captured on disc needs to be of uniform design and, if done in a series of sheets (presumably the case), there should be sufficient overlap that sheets need not be taped together for the photographing of any frames. The overlapping areas should be identical (except at transition edges of projections), and their size should be such that when registered on the camera board, a standard set of camera movement parameters can be used. Needless to say, stable-base material must be used to prevent change of size or shape of the map sheets.

(9) Separations used for specially prepared maps should be by feature and should be consistent not only within a series of a given

sort will be more effective than any conventional type, and although it seems unlikely that hardcopy equivalents of soft fonts would capture well, the notion could be investigated.

(4) Having mentioned that the legibility criterion may affect specific design choices, it is important to point out that degree of legibility itself is going to be a pervasive design decision for any map specifically produced to be captured on a video disc. It seems most reasonable to aim for clear legibility (not "barely readable" or "mostly legible") for at least two reasons. First, if one is tailor making a product, one should not be satisfied with blurry images. Second, even if the illegible or poorly legible parts of an image are "unimportant", it is uncomfortable to look at a blurry image, and it probably results in psychological and visual stress as well as a poor impression of video map imagery on the part of those making decisions about whether or not to use the technology.

(5) Placement of lettering on maps designed for video discs should also depart somewhat from the conventional. A long river, for example, might be labelled only twice on a conventional map sheet but should probably be labelled several times if the map is designed for capturing on a disc. On a conventional map, labels of areas are often spread out such that they would not show in their entirety on any one disc frame. A limit on type spread would be wise on specially designed maps. A general bias toward compactness of point labelling would also be useful; two-word labels are more likely to show up in their entirety if the second word is positioned below the first rather than to the right (^{Fort}Belvoir rather than Fort Belvoir). This compactness of placement should not be confused with compactness of spacing, however; letters spaced too closely will run into one another on the video image and legibility will be decreased.

(6) Color choices are undoubtedly a concern if one is designing maps for video discs. A few observations in this study demonstrated that color choices do need special attention, though little can be offered here as concrete suggestions or guidelines. One must first consider the very question of whether to use color. Black-and-white monitors have higher resolution than color monitors, and at RCA we had a chance to see a black-and-white image on a monitor directly connected to a return-beam vidicon camera that produced a degree of legibility far above that of any of the color imagery we saw of comparable-size map areas. On the other hand, color is very effective for area symbolization and, in fact, broad areas of differing color are easily distinguished in an image even when everything else on a map is illegible (see the frames with whole topo sheets on the ETL disc, for example). Assuming that color will be used, then specific choices become the issue. Black lettering over red is an example of a problem combination. Making blue items legible required moving the camera in closer in our exploration of maps with the camera at Online, Inc., but these investigations did not involve controlled experiments and it may have been the fineness of the blue lines (rivers, grid lines) rather

area being viewed. One needs to know location as well as area size, however, and some indication of location on every frame (or perhaps every other frame or frame cycle in a spatial checkerboard) seems well-justified. On a disc on which they are insufficiently frequent, the manual search is frustrating because one can easily move long distances among unlabelled frames while missing a labelled one. At least one system gave a digital display of a corner coordinate; this has the advantage of eliminating the need for location labels on the map itself and the disadvantage that the imagery is no longer "self-contained" (one could not access the locational information using the video disc player only). Assuming the labels are to be on the map, they should cycle according to the map capture area so it is predictable to the user where the location labels will be found.

(2) Minimum size of symbol elements must be controlled. The need to control the minimum point size for type is reasonably obvious, but such things as degree signs and small point symbols must also be chosen to be visible (or avoided). Perhaps even more difficult, symbols with small-size identifying features must be designed with care. A dot with a surrounding circle (°) is a common symbol, for example, and the critical size is not the height of a whole symbol but the space between the dot and the circle. Likewise, open lettering, dotted lines, sets of small islands, and loops in contours or other linework (ξ) all involve a small "open space" that must be above a critical size to be seen clearly on the monitor. Similarly, a spring symbol of the usual shape () must have a visible tail and it is that subfeature, not the area covered by the symbol as a whole, that is critical.

(3) Choice of lettering styles and specification of their minimum sizes may require departure from the conventional. This departure should be small if the map capture area is chosen to approximate the area capturable on conventional maps. Preliminary observation (App. D) indicates that condensed and light type styles should be avoided or only used in larger sizes.

Another consideration with lettering choices is the familiarity of the words they will form. In observing disc imagery of foreign areas, it is noticeable that lettering does not become "barely readable" at the same size as on maps of domestic areas.

To give the most visual cues in the least amount of space, lower case lettering should be used (rather than capitals) for as many items as possible. While it takes a larger point-size for lower case to be legible, the letters take up less space and have greater shape variety in lower case form.

Finally, the notion of "soft-fonts," lettering designed for digital video display, may have some relevance to lettering design for maps to be captured on video disc (Schmandt 1980), though it is not clear just how the concept might be applied (processing of imagery possibly?). It may be that specifically-designed lettering of some

uses larger and bolder lettering and point symbols on a 1:50,000-scale map, could it not be an exact 4X "enlargement" (with a 20 cm map capture size) of a map at 1:200,000 on which a 5 cm width is the map capture size? Theoretically, the answer is yes, but anyone who has tried to design maps at considerably larger than final size knows how difficult it is to design for great amounts of reduction. In effect, it is a reduction-like process that is involved if one is making a map from which portions greater than about 5 cm in width will be captured again, see App. C for details). If the map maker is working at a scale such that 5 cm portions will be captured, the temptation to put on a symbol that is unreadable will not be there because the symbol would be unreadably small at the scale at which the person is working.

There is another reason for suggesting this approach of producing a map such that the desired earth area falls within a specified map area. If one specifies that 10-km, 50-km, and 100-km earth widths should be capturable on the disc and one maps at three scales such that 10, 50, and 100 km on the earth are represented by 5 cm on each of the maps (1:200,000, 1:1,000,000, and 1:2,000,000), then the same minimum type size, line width, symbol size, and so on apply to all three series. The designer can then concentrate on content selection, graphic cues to the size of area represented (Eastman 1980), and other design issues. The relative "looks" of the three sets of maps would be representative of their relative "looks" on the monitor, and anyone viewing the original maps would not have to compensate mentally for the various size (map) areas that would be captured on the disc.

The various ranges of sizes of map area that can be captured from different map types (topographic, generalized base maps, and relief maps without lettering) suggest that not all map types need be designed for the same map capture size. The approximately 5-cm size seems to be appropriate for topographic maps, but it seems reasonable to choose one map capture size for each general map type, adopt appropriate minimum-size standards, and then scale the desired earth area into the map capture area. If a 7-cm standard were adopted for general base maps, then whether it is Europe, Germany, or Niedersachsen to be depicted, the area would be scaled to fit within a map area 7 cm wide. Relief images could be designed for even larger map capture areas.

While the notion of scaling original maps so that the desired earth area falls within specified map capture areas is the key notion presented here, there are also a number of specific design items that would have to be considered in developing design specifications. Among those that came to light during this investigation were:

(1) The location grid needs to show up in a predictable manner and, more importantly, be labelled in a predictable manner. One disc we saw had frames such that the UTM grid lines were always in the same location (Perceptronics), and this arrangement seems to have merit. There was also at least one example where the grid lines were always at the same (earth) spacing, thus serving as a graphic cue to the size of

The size of map area that can be captured is such a critical concept here that it needs a term. "Map capture area" shall refer to the size of map area that is being captured on a frame, regardless of the scale of the map being photographed. "Earth capture area" will refer to the size of earth area on a frame, which is dependent both on scale of the map being photographed and the map capture area. Both will be expressed most often in widths (map capture width, earth capture width) such as 5 cm or 50 km. Because of the aspect ratio of monitors, on which height is $\frac{3}{4}$ of the width, the area covered will be $\frac{3}{4}$ of the square of this width.

The size of the map capture area is not an absolute and does depend on such variables as the camera quality and the number of lenses being used and upon the size of the type and (in extreme cases) the color of symbols within the map area. In a trial look at a variety of topographic maps on a monitor attached directly to a video camera (at Online, Inc.), the clearly captured image ranged in width from under 3 cm to about 6 cm (note that this refers to a sharp image, not a barely readable or tolerable one). The troublesome items that required bringing the camera in close were such things as: smallest lettering size, umlauts on German lettering, small point symbols, and certain color combinations (black lettering over a red area symbol, orange lettering on white). A look at several page-size general base maps gave a range from about 4.5 to 11.5 cm, an increase due to the larger size of the smallest features. A computer-plotted three-dimensional view with no lettering was clear at over 15cm, and a similarly very general shaded relief map on the ETL video disc showed up clearly when the width of map captured was about 25 cm.

The implications of all of this are of great importance to the design of maps for video discs. First, one must ask whether such small pieces of maps are likely to be meaningful. After all, it is context that gives spatial meaning to symbols on maps, and small portions have little context. Second, if those are the map capture sizes for conventional maps, one must ask whether redesign could help matters. Assuming it could, how should maps be redesigned for video disc? Stated more clearly, given that a certain amount of area and content must be present for an image to be meaningful, how do we design maps such that meaningful areas can be captured on the frames of a video disc? One can take the approach that DMA did with their 1:50,000 scale topographic map (Fulda area, "decluttered" for video) and generalize content and set larger-size lower limits on type size and symbols so that a larger size map area can be captured. Alternately, one could specify the amount of earth area that needs to be available per frame and then design a map at a scale such that that amount of area falls within the area of map that is clearly capturable (about 5 cm). In other words, one would be designing within small image spaces, a practice that would not allow one to put inappropriately small symbols on the map.

This alternative may seem to be an unusual one; after all, if one

III. QUESTIONS OF DESIGN

The matter of design, in the context of video disc map display, must be divided into at least three major categories:

- (1) design of the maps that are recorded on the frames of the disc;
- (2) the design of the disc itself, i.e., the sizes of areas captured on frames, the sequencing of frame overlap, and so on; and
- (3) the design of the system including the hardware, software, and data bases.

The three categories will be treated in turn here, followed by a fourth subsection of comments concerning the design of discs using existing maps.

Design of the Maps

Discussion of the "design of the maps" that are recorded on video discs is primarily, though not entirely, a discussion of their graphic design, i.e., the scheme of the visual elements in relation to one another. The term "map design" in conventional context also includes the selection of content and the scheme of the map series, atlas, or other context in which it appears. This "context" aspect does enter into discussion of video map design as well, but one must realize that something analogous to "map series design" is subsumed primarily under the design of the disc and the design of the system in the case of video discs.

One of the most fundamental observations one can make in looking at video disc map images on a standard NTSC monitor is that only a very limited area of a physical map can be displayed as a clear (non-blurry) image. One of the greatest temptations in reading about video discs, without viewing any, is to assume that 54,000 "maps" can be put on each side of the disc. Even the skeptic who questions how clear a topographic sheet would be on a television screen is probably going to be surprised to find out how very small an area must be recorded on a frame to retain a high degree of clarity. While it varies somewhat with the design of the map, generally the figure of 5 cm (i.e., roughly 2 in.) for the width of a topographic map section is in the right vicinity for a really sharp video image (see App. C for a detailed analysis). The symbolism can be read even when it is not sharp, but even if one allows for that, the area that can be captured is still quite limited (even three times the width for a "sharp" image is only 15cm and although one can read "most" of an area that size, a topographic map image of that size will not be sharp).

Summary

In sum, coverage here of major terminology associated with video discs included the distinction between industrially-formatted optical video discs (of interest here) and other forms of video discs. Items mentioned also included related equipment, such as video camera and monitor, and disc variations, such as hybrid and floptical. Video disc players and access mechanisms as well as a brief summary of the steps in disc production have also been covered here.

With this brief examination of the technology and vocabulary, we can now look at the map design issues involved in video disc display of maps.

X, "did" a certain video disc is actually quite ambiguous. (A far more detailed listing of steps is shown in Figure 11 - 1, included here with the permission of Perceptronics).

Generally, some agency or company wants a video disc for a specific purpose and has at least a general notion of what images should go onto it. This agency or company usually will also fund the disc, and is generally referred to as the client. The client is sometimes the user of the disc as well, but not necessarily. One can quite imagine ETL as the client and a group of commanders in Western Europe as the intended users of a disc.

The next stage in the process is to gather all the visual material to be recorded, develop specifications for camera work, physically arrange the material, and record the images. This step is called pre-production of the disc, and those doing it might be called the pre-producers. This stage is actually a very complex one composed of many very critical substages. It is in many ways analogous to map planning in that it is this set of activities that will lead to the meaningful display of information or to nonsense. This stage is also referred to as the formatting of the disc, especially when one is referring to the filming itself as well as the other steps.

Before the disc can be made, the pre-mastering process of putting the imagery onto a suitable film must be done. This pre-mastering is often done neither by the pre-producers nor by the company doing the mastering, probably because such services are performed for the motion picture industry and thus have a far greater range of purposes than solely preparation for video discs of the sort discussed here. (Interestingly enough, one company, Disc Information Systems Co., Ltd., has recently formed as a separate entity from the parent company, Computer Camera Services, to handle the rather distinct needs of information management as opposed to advertising and other higher-cost, higher-creativity needs.)

When the pre-master tape has been completed, the actual production of the disc, or mastering, takes place. From the master disc, which serves physically as a mold, copies are made in the replication process.

The next phase might be marketing, but to date, map discs have been involved in any sort of commercial mass marketing. While the systems in which they were embedded were often "being sold," the discs themselves have essentially been research and development efforts, primarily for military purposes. Thus, examination and evaluation, rather than marketing, has been the final phase.

(2) Include reversible zoom (allowing one to go back through the same images after having "pulled away a from the earth's surface").

(3) Mark with an overlay rectangle the forthcoming segments in a zoom toward the earth, and the previous segment in moving away from the earth. (Use a different marking system, such as a different color, to distinguish them.)

(4) Use overlap that allows ready recognition of direction of movement.

(5) Aim the disc at showing the capabilities of the disc, not its weaknesses.

(6) Consider supplementary images centered on important features.

(7) Include informative slates.

(8) Place a transparent grid over the maps with overlapped frames marked (especially for the zoom level that will be most used). Study it for problems such as names that will never be wholly within one frame. Consider supplementary type or replacement type if possible.

(9) Use the same grid to evaluate the adequacy of locational labelling. Add supplementary labels if necessary.

(10) Look at maps under a camera and check the adequacy of readability at chosen map capture sizes. All material should be examined if possible.

(11) Take note of any troublesomely small type features or symbols. Consider supplementing with exaggerated umlauts, accents, and point symbols.

(12) Include provision for a proof tape or proof (DRAW) disc (reportedly a California firm does video DRAW discs).

(13) Rearrange any legend material so that symbol and explanation will appear in the same frame, graphic scales will make sense, and text can be read. Text should be retyped if it cannot be logically captured as is (such as a paragraph that is too wide to capture on a single frame).

(14) If one feature is dominant within an area of coverage and is the "landmark" of locational reference (e.g., Fulda Gap), one might consider small arrows at grid intersections pointing to that feature. (The "Where am I" question was a dominant one in looking at disc imagery.)

Summary

Design issues can be divided into three categories: the design of the maps that are recorded on the disc, the design of the disc, and the design of the system. The design issues surrounding the maps themselves stem in large part from the fact that only a small area of something designed for normal reading distance can be captured on a single disc frame. This leads to the notion of designing maps for discs such that the desired area per frame fits within the map area capturable on one frame. Other map design issues include: grid markings relative to frame position, minimum size features that are capturable, lettering style, acceptable legibility, lettering placement, color choices, the concept of meaningful area, sheet design in relation to camera movement parameters, feature separation, coordination of design at varying scales, and alternative means of generating the maps. Design issues associated with the disc include: size(s) of images to be captured, overlap, zoom, sequencing on the disc, slates, and the capture of critical areas. System design issues include the access mechanisms, the use of color separations (vs. capture of the composite image), reversible zoom, and hardware/software/disc generality.

The general issues and problems are involved whether maps for the disc are specially designed or not. A separate check list of ideas for possible improvement of discs with conventional maps include many of the above notions plus checking under a camera and adjusting the small troublesome items and inadequate locational labels.

IV. FURTHER DESIGN WORK IN VIDEO DISC MAPPING

Suggestions for further research into the design issues associated with video disc map display fall into two broad categories: general approaches to improving design, and research into specific questions.

General Suggestions

In the general category are a number of ideas and suggestions for approaching design improvement. They include:

(1) As strongly implied in the previous section, there should be experimentation in constructing maps for video discs at a scale determined by the amount of earth area needed at one time on the display unit. For initial efforts, current topos or their separations should be reduced photographically for guide images, then redesigned so that symbols are distinguishable and crowding is controlled. This should be attempted for varying scales, and the designer(s) should bear in mind that graphic cues to scale (or "amount of area visible on the screen" in this case) are desirable. Initially, products need not be printed, but they should be constructed in the same way that they would be for printing (in separations). Some trials, whether successful or not, should eventually be printed for sharing among researchers to avoid duplication of effort.

(2) In attempting to improve map and video disc design, it has to be recognized that experimental determination of every parameter is impossible. Rather, design needs to be looked at in a wholistic fashion, and ideas need to be tried and evaluated in a manner that is pragmatic but sound. In effect, when a design idea seems to have merit, one should ask "how can I check this out quickly and inexpensively and come to a sound conclusion about its effectiveness?" Most of the time, rigorous testing using video discs and statistically reasonable numbers of subjects will not be the answer. With conventional maps, the map maker is a sort of "sample of n=1" who is constantly checking the results. In the case of maps composed of overlays, proof copies are composited for checking before anything is sent to the printer. Likewise, for video disc maps, equipment should be available for comparable "video checking" before anything is committed to a disc.

(3) The equipment that should be available for video-disc map-design development includes a video camera and monitor setup and a video taping unit. As design ideas are tried or tentative specifications are drafted, the designer should be able to see the effects of the video transformation (a sort of "video proof") by looking at it under a video camera. In the routine construction of maps according to specifications, one should also be able to look at a

"video proof" to catch problems; in other words, each map should be routinely examined under the camera. Some design phenomena (such as desired overlap) are temporal in nature and a videotaping unit would provide "proof material" for these sorts of features. Note that these pieces of equipment would be useful in experimental testing as well as in these checking procedures).

(4) A video disc player and collection of existing discs would be another useful set of items in a developmental lab. Copies of the maps captured on the disc should also be available. This equipment would serve a very different function from the "proofing" equipment. It would, above all, help generate ideas, and it would provide some indication of how much deterioration of image takes place when the whole filming, mastering, and duplication process has taken place.

(5) In producing any new discs, the main notion behind them should be to use as much of what has been learned as possible, and they should place emphasis on the positive aspects of disc opportunities. Frames with whole topo sheets or portions too large to be readable, for example, are obviously useless and should not be there. In teaching map design in the classroom (i.e., design of conventional maps), one of the worst strategies is to make every student "rediscover" basic design principles by trial and error and another is to teach on the "how-not-to-model" (always telling students what they should not have done and asking them to tell what is wrong with other maps). Such techniques never tell the student how it should be done, and likewise making discs that do not avoid the known pitfalls in the first place (and do not demonstrate the best images for the most well-defined purposes) is not a good strategy in developing map applications of video discs. Video discs should be produced with high quality images and using the best practices possible.

(6) Because rigorous perception experiments cannot be the basis for making all design decisions and because a sample of one (the map maker or designer) is a biased sample, it would be useful to develop short questionnaires and use small numbers of people (who are not otherwise involved in the project) to check the viability of decisions. For example, one might set a section of map under the video camera and ask five or six people to: tell how many different color areas appear on the map and indicate where they are, tell how many different line symbols there are and describe or identify each, do the same for point symbols, read all the names, rate the general quality of the image, and rate the "spatial usefulness" of the information displayed. Such a procedure would soon reveal if the map maker was seeing shades of color because they were known to be there and so on, even though such testing is by no means rigorous in the usual sense.

Rigorous Experimental Work

In the area of research into specific questions, calling for more careful experimental study, one can simply go back to Chapter III and go through the numerous issues concerning the design of the map, design of the disc, and design of the system to find a plethora of items that could be subjected to experimentation (location grid design, minimum feature size, minimum lettering size, etc.). Most of these problems, however, will probably be approached satisfactorily (assuming limited resources and personnel) by other means, i.e., by the checking procedures in 2 and 6 above. Among the problems that seem most likely to need careful experimentation are:

(1) The zooming sequence. If maps are designed differently for different scales, what features make the various images recognizable as subareas or superareas of a previous image? Does it help to move the camera away from the larger-scale map (resulting in a blurry image) until the earth area covered matches that covered within the map capture area of the next scale map? Can people learn the zooming strategy so that it becomes meaningful? Are there individual differences in ability to deal with the phenomenon? Video tape could be used to experiment with the zooming problems.

(2) The matter of overlap. It is already known that about 75% overlap is needed to make it easily recognizable that a viewer is moving in a given direction over the terrain. But it does seem quite possible that there are different overlaps required depending on whether the user is trained to deal with it, should recognize it without training, or should find the movement "comfortable". The overlap problem is one so new in mapping (and of such potential importance) that it warrants close study.

(3) The ability of people to deal with small portions of maps. Like the problem of overlap, this is something that is more or less new in mapping. The video display, in current form, in effect eliminates peripheral vision in map use. Such a drastic modification of conditions raises not only questions of whether people in general can deal with it but whether there are significant individual differences in that ability and whether training programs are helpful or if the most important factor is restricting its use to certain applications where that type of training is not necessary. Again, video tapes would be a reasonably inexpensive means of experimenting in this area. This area is also important in contexts beyond that of video disc use; any displays on monitors, whether from video discs or from digital construction, involve limited resolution. The problem of ability to deal with the equivalent of small map areas will be an issue even if and when digital development eliminates the need for video discs.

Summary

In sum, most of the future work that needs to be done is in the realm of development work, dealing with design problems in realistic context and defining broad parameters, rather than in rigorously-designed perceptual testing. That is not to say the latter is unimportant, but it is time-consuming and costly and should be directed to the special problems that most need that type of treatment.

In general, the specially-designed video maps should be tried, keeping in mind that perceptual experiments cannot solve all problems. The video camera with monitor and videotaping should be used to "proof" both experimental maps and maps done routinely for video disc (should we reach that stage). A video disc player and collection of current discs should be available for use in design development though the role would be one primarily of idea generation and general understanding of the medium. New map discs produced should be made to exploit the useful aspects of discs and should not include images that can be predicted to be unsuccessful. Short questionnaires directed to small numbers of people could be helpful in uncovering problems that are not noticeable to the designer.

Specific experimental research is warranted on the topics of zoom design, overlaps, and users' abilities to deal with the small map areas displayed on a video monitor.

V. THE FUTURE OF THE VIDEO DISC FOR MAP DISPLAY

Several items came up in the course of this investigation that did not fit clearly in previous sections yet are sufficiently important to be included here. Generally, they relate to the future of the video disc as a map medium, and they include: the general role of the video disc in map display, the matter of what mapping applications would be most suitable to video disc technology, the alternatives to video discs, and potential changes in technology that will affect the usefulness of video discs.

The Role of Video Discs for Map Display

The predominant view of the role of the video disc for recording topographic sheets was that it is an intermediate technology in the transition from the paper map to digital maps. There is a need for fast retrieval of map information but digital discs are still not ready to handle the load, and all the digitization necessary to work in a strictly digital system will take a very long time. Meanwhile, maps can be captured on discs fairly quickly and computer power can be used in conjunction with them in a very meaningful way.

Such a viewpoint causes one to ask whether the technology will be out of date by the time it is reasonably well developed, and if so, is it worth the effort. The answer to whether it will soon be outdated could well be yes, but even so the effort is probably worthwhile. One way or another, video images are going to be important for a long time in map display and even if the use of video discs is discontinued in a very short time (for map display), they are providing experience in video display problems that goes beyond current digital experience. (One's micro cannot be used currently to produce digital images panning the equivalent of topographic maps of Germany.) But there are also real possibilities that they will have a role even when digital developments eclipse them in the main, just as pen-and-ink technology maintains a stubborn role in mapping after the development of scribing and computer mapping. Whether the video disc retains a lasting role or not will depend partly on the speed of development in the digital area, partly on how much funding goes into video disc research and development, and very much on whether people come up with ideas for exploiting the technology and then can carry them out.

Mapping Applications Suitable to Video Discs

For what sorts of map applications would a disc be useful? One needs either urgency of the retrieval capability (e.g., military needs) or high enough volume of demand to make the disc economically feasible. Content must be meaningful when displayed with limited resolution, the environment must be one in which the hardware can operate, and the

content must be reasonably unchanging or there must be a system capable of accepting change information and overlaying it. Finally, the environment in which the material is used either has to have a high volume of map disc demand or it has to have other uses for the video disc equipment. Among the most appealing uses, then, would be for road information since need can be reasonably well-defined (configurations of road interchanges, for example, in addition to the sorts of things currently on road maps), the content is reasonably stable while changes are terribly important and could be overlaid, and there is widespread need for the information. A second would be locational maps, a sort of atlas composed of numerous simple but meaningful maps indicating where things are. With the progress in developing geographic names files, a next logical step is to show the feature graphically within the local or regional context. Such efforts would be major ones, but like bibliographic search systems, they would be difficult to give up once available.

Alternatives to Video Discs

The issue of alternatives to video discs is an interesting one and certainly has implications concerning their viability. Everything from the paper map, to microforms, to conventional digital storage on magnetic tape or disk, to video tape, to digital discs to photochromic technology can be considered alternatives depending on the application. The viability of each as a competitor depends upon context. In one sense the list is indicative of the delicate position of video disc technology; in another it suggests a versatility of application that is perhaps unrealistically broad.

Potential Changes in Video Disc Technology

Imminent, or potentially imminent, changes in video disc technology and application are also affecting the viability of its position in the mapping world. The small map capture size is currently a drawback, but monitors of twice the (linear) resolution are readily available, thus with approximately four times the areal resolution. If one could readily combine four current frames onto the monitor, this would allow capturing an area twice the width (four times the area). This would be a significant advancement toward being able to capture meaningful areas. Developments in the DRAW (direct-read-after-write) disc area may alleviate both expense and inflexibility problems. Small improvements in any part of the process that would allow slightly larger map areas to be captured clearly and less expensively would make a significant difference in disc viability.

Appendix A

ANNOTATED BIBLIOGRAPHY

Selected Video Disc and Related Literature

Compiled by Gustave W. Rylander

Adler, D. (1981), "Pressing Problems for Videodiscs", Adweek, March 16.

Brief discussion of the potential stifling of the consumer video disc market, attributable to the shortage of production facilities. Facilities shortage has prompted RCA to refuse to custom-press discs for studios desiring to distribute the discs themselves and not through RCA licenses.

BDM Corporation (1983), "Staff Planning and Decision Support System for Transition to C² Survivability", Staff Officer's Manual, January 24, BDM/W-83-034-TR.

Describes microcomputer-based Staff Planning and Decision Support (SPADS) system, a command/control, decision-making, and coordination system for military commanders. Discusses system design, which incorporates standard military maps accessed from video discs, with overlay computer graphics, system elements, and operational capabilities. Many figures and diagrams of SPADS.

Bejar, I. (1982), "Videodiscs in Education", BYTE, June, pp. 78-103.

Explores hardware, software, and "courseware" issues of integrating the interactive video disc into the classroom, using the context of a project involving an elementary mathematics course at the Educational Testing Service (ETS). Major areas of concern include choice of appropriate video disc system, transportability of computer graphics software, and development of video disc authoring systems to support courseware. Proposes an axiom: "Lesson = Instructional Logic + Instructional Content". Lists: "Vendors Supplying Interactive Videodisc Equipment", Pascal procedures that support commands for a DVA Player.

Bolt, R.A. (1979) Spatial-Data-Management, MIT Architecture Machine Group, DARPA Report.

Describes a system that uses spatial location (e.g., series of photographs of faces to which one can point) as an accessing

mechanism to information. Some geographic items included, such as a zoom sequence from satellite image to street map of Boston.

Bowen, C.B. (1979), "A Survey of Videodisc Applications in Industrial Training and Development", Nebraska Videodisc Design/Production Group, University of Nebraska - Lincoln.

Proposes twelve criteria (eight due to Sony's Video Product Division) for effective use of videodisc technology in industrial training/development: 1) multiple playback locations, 2) frequent usage of a single disc, 3) need for multiple copies of a single disc, 4) need for a variety of disc applications, 5) need for random access/branching, 6) need for good picture quality, 7) slow replication time acceptable, 8) remote location not essential, 9) dedicated regional training centers servicing learners, 10) need for a stable visual data base, 11) both group and individual instruction, and 12) no recent commitment to other media. Targets the automobile, insurance, utilities, electronics, merchandising, extraction/processing, and medical industries as prime potential users, based on these criteria.

Ciarcia, S. (1982), "Build an Interactive-Videodisc Controller", BYTE, June 1982, pp. 60-74.

Outline of a method for interfacing a personal computer with the Pioneer VP-1000 Laserdisc Player. Overview of capacitance vs. optical disc encoding, CAV vs. CLV operating modes, control codes (required for interface) and data embedded in the vertical blanking interval, and system design with varying degrees of hardware/software intensity. Insert: JPL [Jet Propulsion Laboratory] puts Planets on a Disc" [RSS (ed.)]. Illustrations: VP-1000 Player, Laser Light beam path, interface circuit, binary control codes, screen displays, and Assembly code Listing of control algorithm.

Clemens, J. (1982), "Video Disks: Three Choices", IEEE Spectrum, March, pp. 38-42.

Compares the three (incompatible) types of video disc systems: Laser optical disc (LOD), capacitance electronic disc (CED), and video high density (VHD). The production process; the tradeoff between high frequency/high signal-to-noise ratio and resolution; NISC-specified rotation speed; the relationship between playing time, recorded wavelength, track width, and rate of rotation. Flowchart: production process. Table: "Video-disk System Parameters". Insert: "Sales of Video-disk Players are Growing" [Gadi Kaplan, Senior Associate Editor].

Command and Control Microcomputer User's Group (1983), "Video Disc: An Integral Component of Composite Technologies for Training and C³I", C²MUG Bulletin, April, vol. 2, no. 4, pp. 1-5.

Brief overview of some of the existing mapping applications of video disc systems. Reviews laser disc technology. Discusses computer-generated "surrogate travel" imagery (e.g., the "Dar-El-Mara" project) vs. filmed imagery (e.g., the Aspen project, conceived by MIT's Machine Architecture Group), and Perceptronics' enhanced surrogate travel systems ("Talking Maps" and "MICROTRAVEL"). The use of discs in image processing for "image matrixing" (to increase effective resolution), and decluttering and composition (to facilitate map simplification and feature selection by the user). Discusses the recent Tactical Video Mapping (TVM) system, with increased collateral imagery, annotations, and communications capabilities. Training and simulation applications of video discs.

Costanzo, D.J. (1983), "Mapping Applications of Videodisc Technology", paper presented at National Computer Graphics Association Conference, June, Chicago, IL, 10 pp. (Available from ETL.)

Technical factors affecting map storage and access on analogically-encoded video discs: frame size, percentage overlap, number of levels, hardware/software. Specific mapping applications include: 1) video map atlas, 2) interactive map product catalog, 3) factor map overlaying, 4) map teaching aid, 5) storage of perspective terrain views, 6) navigation aids, 7) moving map, 8) multiple data display, 9) storage of remotely-sensed imagery. Discusses additional USAETL video disc research. Tables: disc storage capacities under various conditions. Photos: map frames.

Constanzo, D.J. (1984a), "The Potential for Video Disc Technology in Cartography", prepared for the International Cartographic Association, Perth, Australia, August, 15 pp. (Available from ETL.)

Includes discussion of the technology and advantages and disadvantages of optical video discs for map display. Lists the steps in creating a map disc and describes ETL research on discs.

Constanzo, D.J. (1984b), "Requirements and Specifications for Cartographic Video Discs", presented as a poster paper at the 1984 Army Science Conference, June, and appearing in the Proceedings of that conference, 16 pp. (Available from ETL.)

Discusses map disc development including: planning, gathering source materials, filming, videotaping, mastering, replication, and software development.

Daynes, R. and R. Nugent (1980), "Designing and Producing for the Videodisc: A Progress Report", Project Paper No. 3, September, Nebraska Videodisc Design/Production Group (NVD/PG), KUON-TV/University of Nebraska - Lincoln.

Project initiated by the Corporation for Public Broadcasting to investigate the potential of video disc technology for educational television. Classifies systems into three levels, each with a specific target audience, based on "player performance" or "level of interaction" (Level I: little memory, no processing power; Level II: industrial model with built-in programmable memory; Level III: Level II system interfaced with a home computer). NDV/PG authored four instructional discs and defined seven sets of frames for each one: 1) orientation, 2) content, 3) decision, 4) strategy or comment, 5) summary, 6) problem, and 7) help. Description of the production process. Tables: functional capabilities of each level, Level II MCA Discovision Player Functions. Diagrams: Level III system configuration, authoring format. Lists: Reports on video disc technology by NVD/PG.

Daynes, R. (1982), "The Videodisc Interfacing Primer", BYTE, June, vol. 7, no. 6, pp. 48-59.

Demonstrates enhancement of capabilities of video disc systems when interfaced with a microcomputer. Classifies systems into three levels of interactivity. Describes capabilities and compatibilities of various commercial system interfaces and includes addresses of manufacturers. Discusses the Nebraska Videodisc Design/Production Group's experimentation with the "overlay" interface (computer-generated text over NTSC video) as well as its efforts to develop a computer-controlled off-line disc editing system. Includes program command listings for various tasks, a detailed disc design/production flowchart, and a glossary.

Eastman, R. (1981), "The Perception of Scale Change in Small-Scale Map Series", The American Cartographer, vol. 8, no. 1, pp. 5-21.

An experiment with symbol size, density, and attribute variability to examine their influence as graphic cues to scale (or their effect on judgments of amount of area covered by a map). An earlier, unpublished study of graphic cues to scale (by Arthur Robinson and Randall Sale) is summarized in the appendix. Not about video discs, but the concept is an important one for video

disc map displays as well as for conventional paper maps.

Fink, Donald G., ed. (1957), Television Engineering Handbook, NY: McGraw-Hill Book Co.

Reference on certain technical aspects of television including resolution.

Goldstein, C.M. (1981), "Potential Impact of Optical Disc Technology", in King, D.W. et al., Telecommunications and Libraries: A Primer for Librarians and Information Managers, Knowledge Industry Publications, Inc., pp. 121-136.

Distinguishes between optical digital discs (DRAW, Low error rate, good archival quality) used for computer mass storage, and optical video discs (high error rate, ability to mix digital and video information on a single disc), which have great potential for data base publication. Discusses general optical recording technology, consumer vs. industrial disc players and their associated disc formats, and disc production. Implications of both technologies for on-line storage: cost comparisons, access to full text, and distributed vs. centralized information delivery. Comparison of optical disc media with microforms. Implications for libraries.

Gunther, G. (1978), "The Optical Videodisc", Bulletin of the American Society of Information Science, December, vol. 5, no. 2, pp. 103-104.

Reviews characteristics of the optical videodisc (archival long life, very high information density, stable storage characteristics, variable speeds, freeze frame/random access, microcomputer interfacing capabilities, and low replication costs) and discusses two categories of use for the information manager: 1) data/document storage and retrieval, and 2) audiovisual programming (with interactive programming).

Herot, C.F. (1980), "A Spatial Graphical Man-Machine Interface", Information Processing '80, S.H. Lavington (ed.), North-Holland Publishing Co., pp. 1039-1044.

Describes a system similar to the MIT Spatial Data Management System (in which spatial location, such as position of a series of faces, is used as an access mechanism). Uses the term "World-View Map" to mean an overall view of what is in the data base. System includes several types of data. An optical video disc is incorporated, but its content is not described here.

rot, C.F., R. Carling, M. Friedell, D. Kramlich, and R.L. Rosenberg (1981), "Overview of the Spatial Data Management System", Technical Report CCA-81-08, November, Computer Corporation of America, Cambridge, MA 02139.

Describes Computer Corporation of America's Spatial Data Management System (SDMS). Purpose of SDMS is to help non-specialists access a data base by "seeing" it and interacting directly with it (rather than through a formal query language). Contains two examples (oil/gas data base and ship data base) of SDMS use. Lists benefits of SDM: 1) simple, natural motion through data base, 2) data base is its own data dictionary, 3) encourages browsing, 4) placement of data conveys information, 5) graphics convey information vividly, 6) system accommodates many data types (in part, due to video disc use). Mechanisms for specifying graphical views, SDMS's graphical editor, query languages that address SDMS's graphical environment, and the system environment are reviewed. Includes a glossary.

oper, K. (1981), "The Use of Computer-Controlled Video Disks in the Study of Spatial Learning", Behavior Research Methods and Instrumentation, vol. 13, no. 2, pp. 77-84.

Discusses the qualities of interactive video discs which can improve research methodology in spatial learning studies. Considers standard pictorial display systems (tachistoscope, slide projector, movie projector, and videotape recorder), alternative pictorial display systems (model photography, and off-line and on-line computer graphics), and computer-controlled video discs. Considers content, presentation, and response recording characteristics of each. Concludes that the interactive capabilities and display detail characteristic of video disc systems makes them superior for spatial learning studies.

ohnston, S. (1983), "Video Disc Technology", MICROFIX Newsletter April, vol. 2, no. 2, pp. 11-12.

Discusses videographic/videodisc capabilities and map production techniques, and impacts of technology on videographic display systems. Describes "MICROFIX System One" video mapping system. Identifies five factors accounting for resolution limits on NTSC color monitors. Estimates that each side of a disc (54000 frames) can store the map equivalent of 300-400 km of ground area, given assumptions about map scale, level of (filming) magnification, continuous map viewing directions (horizontal and/or vertical), and percentage overlap between frames. Identifies military areas of coverage that will be encoded on discs from maps and collateral imagery.

IIT Research Institute:

IITRI's Info Disc 3 (the first two have no maps) contains about 30 map frames of Donnelley maps of Chicago and Denver (specially designed). The rest of the 2000 or so images are text and demonstrate IITRI's method of segmenting for videodiscs. Done early in 1984, this promotional disc is available from Peter Schipma, IIT Research Institute, 10 W. 35th St., Chicago, IL 60616 312/567-4592.

Interactive Television Company:

The disc entitled Fulcrum Maps Vol. 1 was produced in 1983 and contains about 50,000 map frames. Done for an intelligence display system for a Federal agency, it contains a range of imagery of Central America from city maps to about 1:9,000,000 in scale. Release by the agency would be necessary to obtain the disc. Contact: Steven Levin, Interactive Television Company, 1901 N. Moore, Suite 1100, Arlington, VA 22209 703/525-5625.

Jet Propulsion Laboratory (JPL):

The Planetary Image Video Disc, Vol. 1, 1982, is not a map disc but rather has imagery of Mars, Jupiter, Venus, and Mercury. A brief and somewhat inflated description appeared in BYTE, June 1982. It is strictly a research aid and is of little general (public) appeal. A partial data base for access exists at National Space Science Data Center and Washington University in St. Louis. Latitude/longitude can be used to a limited degree. One can access by orbit and image number, filter identification, solar incidence angle, and emission angle. Copies will soon be available from NTIS (5285 Port Royal Road, Springfield, VA 22161) at approximately \$50. The original 300 copies were sold out, but more are being made. Contact: Mike Martin, JPL, Mail Stop 168-154, 4800 Oak Grove Drive, Pasadena, CA 91109 213/354-6065.

Library of Congress (LC):

LC is not involved in any map video disc projects, but has a project in progress that is of close interest in that it involves digital discs and maps. LC is archiving images of prints (non-map materials) on video discs, but its initial experiments with maps, books, and serials are utilizing digital discs (Thomson-CSF). All will be done in black and white. Integrated Automation (formerly Technicon) is doing the project and Schugart (a Xerox subsidiary) and Storage Technology Corp. are involved. LC will have six stations and printers available for the experimental period use. LC did use a video disc in its Cowboy Exhibit (Summer 1983) on

Fort Gordon, GA:

Fort Gordon has the lab for photographing and taping the images. They have done two map discs. 1) One was done in late 1981 or early 1982 and had about 40,000 images of the North German plain. It was done for TACATA at Fort Hood, TX. 2) The second disc was for Fort Bragg, NC, and contained maps of S. W. Asia. Done in 1982, it contained about 54,000 images of 1:50,000 DMA maps and no other imagery. No programming for users or other further work was done with this disc at Fort Gordon. Contact: Mr. Wm. Poe or Major Dooley, Office of the Secretary, US Army Signal Center TASC ETV Branch, Nelson Hall, Bldg. 29801, Rm 113, Fort Gordon, GA 30905 404/791-2345.

Geoview, Inc. (Rosslyn, VA):

Geoview (associated with Interactive Television Company) supervised production of the ETL/USGS/WRSC/NCEL Experimental Map Disc. This disc contains a variety of maps, Landsat images, video travel sequences of map sections, and types of images. It was produced for use in experimenting with access programming and so on. A listing of imagery on the disc is available and discs are available in limited supply. Contact: Daniel Costanzo or Robin B. Lambert (see ETL above), or Steven Levin (see Interactive Television Company below).

Horizons Technology, Inc.:

Working with floptical discs, a project now in progress will include about 100 images from the tape prepared for the ETL disc (see above). Contact: Mel Chaskin or Tom McGraw, Horizon Technology, Inc., 6800 Poplar Place, Suite 101, McLean, VA 22101 703/442-8860.

Interac Corp.:

1) The Target Acquisition (helicopter) Disc was produced in 1980 to sell a system for aerial surveillance by helicopter in combat. The maps were probably of Florida. The project is now rather historical. Few copies were made and they are not available. 2) The Interac Demo Disc was created in 1982 to demonstrate an interactive system. A touch screen was used to move in various directions, and zooming (3 levels) was possible. The maps were topo sheets of West Los Angeles. Few copies were made and they are not available. 3) A third disc is in progress and information should be available in summer or fall 1984. Contact: Mark Dillon, Interac Corp., 6312 Variel, Suite 214, Woodland Hills, CA 91367 213/999-1721.

and be able to plot (overlay) ship position on the frames. It is part of a Spatial Data-Management System and has 1:250,000 DNC and JNC charts plus 3 world maps. Several levels of zoom are included and scroll capabilities are built into the system. About 50 copies or fewer were made; DoD would have to approve acquisition of the disc. Contact: Chris Herot or David Kramlich, Computer Corporation of America, 4 Cambridge Center, Cambridge, MA 02142 617/492-8860.

Donnelley, R.R. (Mapping Services):

Donnelley has produced maps that were on an MIT disc (not those listed for MIT below). These were location maps that might be part of a current events reference disc. They were also specially designed maps (information from B. Petchenik and S. Marland). According to A. Lippman at MIT, they were intended as base maps on which to plot video overlay symbols and the disc is definitely unavailable.

Decisions and Designs, Inc. (DDI):

This company has recorded the monochrome separates from DMA maps. These separates are instantly digitized when the user accesses them and features are combined and are assigned colors through the software. By doing a hardware zoom before the panning, one can pan smoothly; the rest of the accessed frame is available and so is the "next" frame (which is predicted by current panning direction and is digitized and stored so scanning can proceed smoothly between frames). A mini system is used with the disc. 1) One disc has about 12,000 frames and covers part of Korea. No copies are available. 2) A second disc has about 30,000 map frames of S. W. Asia, (esp. Iran) plus perhaps 100-200 photo images. It was done in 1983 for the CINCS Conference. Copies may be available. Contact: Art Farrington, DDI, 8400 West Park Drive, Suite 600, McLean, VA 703/821-2828.

Engineer Topographic Laboratories (ETL):

ETL was one of four clients for the Geoview disc below. They are also the client for another disc (Fulda Gap Area) and may do a hybrid disc. Contact: Daniel J. Costanzo or Robin B. Lambert, Automated Cartography Section (TD-MA), Engineering Topographic Laboratories, Fort Belvoir, VA 22060-5546 202/355-2770 (Costanzo), 202/355-2784 (Lambert).

Appendix B

MAP VIDEO DISCS: A LISTING

In the course of this investigation it became clear that a list of existing discs would be useful. A compilation was begun from site visit notes and phone conversations. A set of questions (see the last page of this Appendix) was developed in an effort to gain reasonably comparable information about the various discs, but these served only as a guideline for interviewing those who had knowledge of discs, and complete information was not available on all of them.

Interestingly enough, the exercise soon revealed the referencing problem with video discs. Titles are often informal, and it is not only unclear what agency, company, or institution should be considered the "author", but the roles of the various participants are not comparable from one disc to another. The system used here is to list the discs according to the best source of information available among those contacted, which in each case is one of the companies, agencies, or institutions highly involved with the disc.

This list contains the information available to the principal investigator as of mid-June 1984. In several cases, the name of the contact person or the telephone number changed even within the limited time during which this information was gathered, but the listings here should be useful as a starting point for some time to come.

Army Communications Technology Center (ACTO):

ACTO does research and development rather than application discs. Their disc work has dealt with training, and they have attempted to show what can be done with discs for: repair, parts, and special tools lists (RPSTLs); maps; and map reading instructions. Their experimental discs are done primarily to develop capabilities for other units within the Army. At least one demonstration disc has some maps, including a few frames of material for basic map training. Contact: Lt. Col. Curbow, Deputy Commander, ATSC/ACTO, Fort Eustis, VA 23604 804/878-4210. Robert Puttcamp, ATSC/ACTO, Fort Eustis, VA 23604 804/878-4587, 4588, was involved in the project and is also knowledgeable about it.

Computer Corporation of America (CCA):

CCA did the Vinson Map Atlas (for the ship "Vinson") in 1982. It contains about 30,000 map images plus pictures of ships and so on from a reconnaissance plane. Its purpose was to get maps on board

Wong, K. and N.G. Yacoumelos (1973), "Identification of Cartographic Symbols from TV Displays", Human Factors, February, vol. 15, no. 1, pp. 21-31.

More readily-available material from the ETL study referenced above.

Unattributed (1980), "Videodiscs: A Three-Way Race for a Billion Dollar Jackpot", Business Week, July 7, pp. 72-78.

Technological incompatibility of consumer video disc products will increase competition. This is less true for industrial products. Describes industrial structure of consumer video disc companies. Consumer confusion due to lack of product standards will slow market growth. Entertainment industry owns software for consumer video disc programs. Lists some early applications of industrial players, including DARPA's project to film maps for video discs.

Unattributed (1983), "Optical Data Storage at the Library of Congress", Technology Watch for the Graphic Arts and Information Industries, vol. 3, no. 7, May, pp. 1-3.

Discusses USLC's efforts to digitally encode its materials [Note: not maps] on optical video disc, in order to promote accessibility and mass, archival storage. Speculates on the plausibility of national accessibility of Library of Congress materials. Diagram: Library of Congress Preservation and Retrieval System.

Wong, K.W. and N.G. Yacoumelos (1971), "Television Display of Topographic Information: Phase II", ETL-CR-71-23, US Army Topographic Laboratories, Contract No. DAAK02-71-C-0045, November, 59 pp.

Investigation into "...the resolution capability of color TV in identifying details from line maps and picto maps, and to establish the relative merits of color and black-and-white TV systems". Phase I has examined B/W TV. Describes: 1) TV systems used (TV cameras, monitors, system set-up), 2) System Calibration (resolution, spectral response characteristics, geometric calibration), 3) Experimental Design (variables: display types, map types and scales, resolution levels, and symbol types; sampling techniques), 4) Data Analyses and Results, and 5) Methods for Hardcopy Output (direct photographic, electrostatic printing, laser beam recording, and electron beam recording). Concludes that: 1) at 9 TV Lines/mm (or an effective resolution of 5.9 TV resolution Lines/mm for B/W systems) alphanumeric characters are almost always readable, and 2) color TV has no advantages over B/W for display of topographic information. Appendices: "Geometric Distortion Patterns", "Programs of Experiments for Individual Subjects".

Corporate brochure comparing interactive video disc systems with videotape recorder systems for various applications. Locates seven Sony system configurations on a graph of "computer power" and "ease of random access and still frame". Table shows specific characteristics of the seven configurations.

Suthasinekul, S. (1980), "Microfilm vs. Optical Disks as a Storage Medium for Document Retrieval and Dissemination", Proceedings, American Society for Information Science, vol. 17, pp. 100-105.

Identifies sixteen parameters critical to the storage, retrieval, and dissemination of documents. Conducts a feature-by-feature comparison of video disc and microfilm systems, in order to facilitate overall comparisons of their utility. Relative importance of each parameter is application-specific.

Unattributed (1979a), "A Summary of Research on Potential Educational Markets for Videodisc Programming", Project Paper No. 1, November, Nebraska Videodisc Design/Production Group, KUON-TV/University of Nebraska - Lincoln, 16 pp.

Summary of two educational market research reports undertaken by Kalba Bowen Associates. Using data for primary and secondary schools, two-year and/or four-year colleges, and adult education programs, examines: audiovisual expenditures, software and hardware markets, market growth trends, subject- or course-related market segments, patterns of use, and distribution of video-related equipment. Examines three "focus groups" as case studies for market research: 1) AV media directions from secondary schools, 2) college professors of business administration, and 3) providers of computer-assisted instruction.

Unattributed (1980b), "Technology Focus: Video discs - A Triquetral Marketplace", Electronic Engineering, September, pp. 129-161.

Technical discussion of the formats and physical principles of the three major types of video discs: Laser optical, grooved capacitance, and grooveless capacitance. CAV vs. CLV discs, coding formats, focusing the laser, radial tracking, time error compensation, and playing modes. Detailed description of the components in the VLP player in the light path from laser to disc surface to decoding photodiode. Many figures: disc construction, recording, mastering, various optical principles, format of CAV disc, electronic circuitry, the laser light path, and the relation between film pictures and video frames on tape. Inserts: Details of the JVC (grooveless capacitance) and RCA (grooved capacitance) disc players.

industry (entertainment) to bear the brunt of developmental costs and market saturation". Reports on ITT Research Institute's work on solving the problems of resolution and individual frame capture. Prototype system uses an image dissector, as opposed to a television camera, which captures an entire page at high resolution. Cost comparisons of this method with storage on paper text. Concludes that savings due to video disc storage/display are more easily achievable in a library setting than in a classroom setting.

Schmandt, C. (1980), "Soft Typography", Information Processing '80, S.H. Lavington (ed.), North-Holland Publishing Co., pp. 1027-1031.

Describes a method of showing type on a video screen such that some pixels are shaded grey to eliminate the jagged look. This increases the "virtual resolution" of the display.

Schmandt, C. (1982), "Interactive Three-Dimensional Computer Space", Proceedings, SPIE Conference on Processing and Display of Three Dimensional Data, San Diego, CA, 5pp.

MIT Machine Architecture Group's efforts to develop an ergonomic data base abstraction that makes the data visible (using true stereoscopic display systems) and allows the user to interact directly with it. Utilizes a six degree-of-freedom digitizer (i.e., it returns x, y, z, azimuth elevation, and roll) for input. Stereoscopic display allows "direct spatial mapping of input to image" and uses video technology to facilitate real-time change and computer interface. Also discusses work station and its implementation and limitations. Illustrations: Media Room hardware and System use.

Sigel, E., M. Schubert, P.F., Merrill, et al. (1980), Video Discs: The Technology, the Applications, and the Future, Knowledge Industry Publications, Inc.: White Plains, NY, 183 pp.

Comprehensive, non-technical introduction to video disc technology. Nine chapters: 1) "Introduction", 2) "An Overview and History of Video Disc Technologies", 3) "The Consumer Market for Video Discs", 4) "Education and Training Applications of Video Disc Technology", 5) "Creating Educational Programming for Optical Video Disc", 6) "Business Programming for the Video Disc", 7) "Video Discs for Information Storage and Retrieval", 8) "The Video Disc and Competing Technologies", 9) "Conclusions". Appendix: "Organizations Involved with the Video Disc".

SONY Video Communications (nd), "Interactive Video", SONY Corp., NY.

in Video".

Rice, P. and R.F. Dubbe (1982), "Development of the First Optical Videodisc", SMPTE Journal, March 1982, pp. 277-284.

Traces the history of the optical video disc from James Logie Baird's idea to record television signals on a disc (1930's), through the technological refinements of Stanford Research Institute (high-resolution photographic plates encoded by a high-pressure mercury arc) and 3M (electron beam recording), to the present state of the art (DRAW technology). Photos: various video disc images and hardware at progressive stages of technological development. Table: "3M Patents Pertaining to Videodisc Development".

Robbins, W., R.P. Freese, T.L. Smith, and R.F. Wilson (1981), "Bubble-Forming Media for Optical Recording -- A New Approach", paper read at IEEE/OSA Conference, June, pp. 10-12.

Discusses the properties of a new video disc material, developed by 3M, which is encoded by the formation of bubbles on its surface. Compares it with the more conventional disc encoding processes: photoresistance, and ablation ("pit" formation). Lists nine important characteristics of the new material: 1) DRAW, 2) high sensitivity, 3) high C/N ratio, 4) archival, 5) mechanical stability, 6) replication by casting/embossing, 7) adaptability to different wavelengths, 8) non-toxic, and 9) read at 0.7 mW.

Rothchild, E. (1983), "Optical Memory Media", BYTE, March, pp. 86-106.

Describes the lack of physical standards for discs, ablative (e.g., Philips, Drexler) vs. bubble-formative (e.g., 3M, Thomson-CSF) encoding, characteristics of tellerium and alternative materials as recording media, erasable vs. non-erasable media, recording error rates, data transfer rates, optical media costs, ease of handling (makes "jukebox" storage system feasible), Drexler's Drexon medium, Philips Air Sandwich, the Burroughs process, Kodak's approach, packing densities, and future materials.

Schipma, P.B. and D.S. Becker (1980), "Text Storage and Display Via Videodisc", American Society for Information Science, Proceedings, October 5-10, vol. 17, pp. 103-105.

Three qualities of the video disc as text, storage/display medium: high storage density, rapid random access, and "ubiquity of display devices (television receivers) and the presence of another

Videodisc Design/Production Group, Project Paper no. 4, University of Nebraska - Lincoln, October, 11 pp.

Brief, non-technical review of video disc system formats. Optical vs. capacitance discs, pre-mastering, mastering, and replication are discussed. Comparison of five disc players: Thomson-CSF, Discovision, Sony, Magnavox Magnavision, and Pioneer Laserdisc. Efforts of Nebraska Videodisc Design/Production Group to explore unique capabilities of various types of systems in relation to targeted audiences.

Paulson, C.R. (1982), "The Video Disc System: A Technical Report by the SMPTE Study Group on Video Disc Recording", prepared for the Committee by Michael J. Doyle, Vice-Chairman, SMPTE Journal, pp. 180-185.

Describes the four basic video disc formats and their associated disc player types: Laser Optical Reflective (LOR), Laser Optical Transmissive (LOT), Capacitance Electronic Disc (CED), and Video High Density/Audio High Density (VHD/AHD). "Each is representative of a technical approach that evolved as a result of organizational goals which are related to market strategy and economies of scale required to penetrate these market segments." Reviews disc production methods. Schematic diagram of mastering/replication process.

Perceptronics (1983), "Overview: Applications of Tactical Video Mapping Technology", May, Perceptronics, Inc., 5 pp.

Describes features of an integrated Tactical Video Mapping (TVM) system: 1) surrogate map travel, 2) map annotation, 3) collateral imagery, 4) user-friendly interaction, 5) interfacing. Army programs utilizing TVM: 1) battleground simulation, 2) command and control, 3) intelligence assessment, 4) planning aids, 5) communication. Perceptronics' efforts to develop technologies for: 1) a ground-controlled Airborne Remotely Operated Device (AROD) for reconnaissance and surveillance, and 2) a Resource Appointment Aid (AID) to assist senior battle staff in making resource allocation decisions. Figure: TVM command/control system.

Pollack, A. (1981), "The Perils of Consumer Electronics", New York Times, March 22.

Discusses the promotional campaign of RCA Selectavision, a commercial video disc player, in light of past marketing failures in the unstable market for consumer electronics (e.g., picture phones, 45 r.p.m. records, quadrophonic sound, etc.). The economics of the disc player industry. Insert: "The First Flops

town; and 2) "map land", a similar journey above a planimetric representation (map or air photo) of the town. Objectives of the disc are to improve mapping research (especially spatial learning research) and spatial data access, and to demonstrate a prototype hardware configuration. Discusses development of the system, including the original filming of the town and the maps and air photos, and its implementation and hardware configuration. Photos: disc frames of map land and travel land. Figures: hardware configuration and camera viewpoints for filming the aerial representations.

Negroponte, N. (1979), "Books Without Pages", copy of manuscript from MIT Machine Architecture Group.

Ergonomic advances brought about by the synthesis of image processing, broadcast television, and computer graphics via raster scan technology. Optical video disc will enable consideration of the human element of this synthesis by providing random access to information (analogous to "paging through a book"), sound synchronization, and spatial cues to one's "Location in the data". Discusses MIT Machine Architecture Group's Media Room and Spatial Data Management System. Illustrations: the Media Room.

Negroponte, N. (1979), "The Impact of Optical Videodiscs on Filmmaking", copy of manuscript from MIT Machine Architecture Group.

Theoretical consideration of the potential changes in the nature of films and film techniques made possible by the use of optical video discs. Characteristics of video discs will allow films to become: 1) personalized, 2) conversational, 3) navigational, and 4) synthesized. Draws an analogy between these new film types and computer programming: both operate "algorithmically".

Negroponte, N. (1982), "Media Room", Proceedings of the S.E.D., vol. 22, no. 2, pp. 109-113.

Conceives of the page as a physical, semantic "chunk" in a book and the frame as its counterpart on video discs. Speculates on "the extremes of human interfacing" and progress to that end at the Machine Architecture Group's Media Room and Spatial Data Management System (SDMS). "The concept includes total immersion of cognitive and sensory apparatuses into an information space..." Discusses future plans for improving the System's cost-effectiveness. Illustrations: Media Room Hardware and SDMS use.

Nugent, R. (1980), "An Overview of Videodisc Technology", Nebraska

user with an unfamiliar environment, to provide spatial data access/management system, and to explore interface between real images and computer graphics. Two types of movie maps: 1) basic, which provides surrogate travel and spatial data access, and 2) using image processing techniques. Describes visuals of driving, synthesized sound, spatially-stored ancillary data, and animation. Two categories of anamorphic map image processing: 1) optical, and 2) video rate electronic.

Marsh, F.E. (1982), "Videodisc Technology", Journal of the American Society for Information Science, January, vol. 33, no. 1, pp. 237-244.

Describes three major video disc technologies: Laser systems, grooved capacitance systems, and grooveless capacitance systems. Distinguishes between optical video discs and optical digital discs, and between consumer and industrial optical video discs. Discusses the encoding and decoding process, disc formats, video disc and digital disc applications, and storage capacities. Presents a formula to calculate storage required to represent one page with continuous-tone photographs, and one to determine the effect of increasing density on optical storage. Tables: "Magnetic Disk/Optical Disk Cost Comparisons", "Storage Requirements of [the National Technical Information Center's] Energy Data Base Bibliographic Data", "Storage Capacity of Optical Digital Discs".

Moberg, D. and Laefsky, I.M. (1982), "Videodiscs and Optical Data Storage", BYTE, June, pp. 142-160.

Examines products, benefits, and storage modes associated with storage of digital information on optical video discs. Distinguishes between optical digital discs (suitable for archival information), and optical video discs (suitable for easily-replicated data bases). Discusses efforts of various organizations to utilize optical disc storage technology, including Lister Hill Center's (medical communications arm of the National Library of Medicine) project to produce a video disc data base of its indexes.

Mohl, R. (1980), "The Interactive Movie Map: Surrogate Travel with the Aid of Dynamic Aerial Overviews", Applications of Interactive Television and the Videodisc, Midcon Professional Program, Session 10, November 4-6, 7 pp.

Describes a computer-controlled video disc encoded with two representations of the environment: 1) "travel land", an interactive, complete, surrogate journey through the streets of a

Carto IV, November, vol. 1, pp. 154-163.

Models the map as a set of "marked fields", or thematic overlays, of: 1) natural phenomena, 2) anthropogenetic (or cultural) phenomena, 3) individual features, and 4) user's priorities. Map image is conceived of as a set of these overlays, stored separately on the videodisc, and retrieved and combined as specified by the user. Characteristics and limitations of digital image processing systems, and the videodisc as a solution to memory, transmission, and data storage capacity limitations. Experiments in recording maps on photochromic glass to facilitate image combination. Author is from the Institute of Geodesy and Cartography (Warsaw, Poland), possibly the only cartographic research institution actively studying video disc technology as it relates to maps. Figures: stages in the video map compilation process, system configuration.

Lehman, D.H. and D.C. Pasterchik, "Digital Processing of Videodisc Map Imagery", manuscript obtained from authors.

Addresses the problems of efficiently storing and displaying Large-scale maps for military command/control systems. Description of the Terrain Map Display (TMD) System, which stores maps digitally to avoid inaccurate analog-to-digital conversions. Discusses the tradeoff between resolution and preservation of context, the clutter problem, the importance of color on raster displays, and scale and coordinate manipulation of the map image. Components of the TMD system: 1) data base - photos of the separation plates used in printing, 2) image processor or Video Frame Store (VFS). Also, hardware architecture, feature control translation, two zooming modes, and aliasing.

Levin, S. (1984), "Procedures and Standards for the Production of Videodisc Maps, and Databases", prepared for the Videodisc Working Group Intelligence Information Handling Committee, January 20 (Draft Copy).

A very informative report pertaining specifically to map display via video disc. Contents include: Technical Background, Production Issues, Production Standards and Evaluation, and Index of Production.

Lippman, A. (1980), "Movie Maps: An Application of the Optical Videodisc to Computer Graphics", Siggraph '80 Conference Proceedings, Computer Graphics, July, vol. 14, no. 3, 11 pp.

Discusses MIT Machine Architecture Group's interactive "dynamic map", encoded on two video discs. Three purposes: to familiarize

Johnston, S., J. Smoot, and C. Findley (1983), "Video Disc Mapping Technology", Technical Note PVATN-83-3, May, Perceptronics, Inc., 15 pp.

Lists applications of maps stored on video discs. Proposes a definition of "video disc map" and provides a dictionary of terms associated with it. Suggests two emerging standards problems: 1) the format of maps on discs, and 2) the definition of a data base describing disc-encoded map imagery. Discusses map scale transitions, resolution limits, map filming methodology, the relationship of disc frame numbers to geographical coordinates, and data base standards in general. Figures: map scale transitioning, filming techniques, and the computer-controlled animation system. Examples of local and global data base files.

Kenney, G., "Survey of User Needs and Specifications for Mass Information Storage Systems", Philips Lab.

Mass Information Storage System (MSS) is defined as one capable of storing one terabit (10^{12} bits) of information. Lists the twelve largest government users of information storage, including Military Command Control Center, Navy Seasat, Landsat - USGS, US Navy Ocean Floor Mapping, DMA, and Census Bureau. Desirable characteristics of MSS include; archival, non-erasable media; high data rates; fast access times; low cost; large media capacity without repositioning; removeable media; volumetric efficiency of machine and media; and expandability to 10^{15} bits. Distinguishes three types of optical video disc MSS: single disc unit, disc pack, and automatic "juke box". Graphs: "Areal Recording Density vs. Time for Magnetic and Optical Technologies", "Access Time vs. Price for Various Storage Technologies". Table: Characteristics of Storage Devices.

Ketchel, J.M., P.H. Sorensen, D.K. Beck, and G.C. Byrne (1983), Interactive Techniques for RPV Mission Planning, Final Report 6260-83-FR-80 prepared for Lockheed Missiles and Space Company, Inc., Austin, TX, by SRI International, Menlo Park, CA.

Describes a test bed project on interactive techniques in mission planning and operations for remotely piloted vehicles. Describes an experiment with the reading of video discs, which used 5 levels of magnification, 4 topographic map scales, and 2 display modalities (B/W and color) for $5 \times 4 \times 2 = 40$ images. Six adult males answered 174 questions on each of the scenes. Magnification was most important in determining accuracy, response time varied considerably with type of question, etc.

Kowalski, H.Z. (1980), "Video-Cartographic System", Proceedings, Auto-

which there was one or more rather incidental map images of the ranch that was described on the disc. Contact: Joe Price, Chief of Science and Technology, Library of Congress, Washington, DC 20540 202/287-5664.

MITRE Corp. (Bedford, MA office):

MITRE produced their first disc with maps in 1976 (possibly the first with maps). The second disc contained the separation plates from DMA maps of the Fulda Gap area of Germany plus an image of the world from space and other material. They have looked into registration problems between frames and can do magnification of parts of the image. Contact: David Lehman, Group Leader, Intelligence Display Technology, The MITRE Corp., Bedford, MA 01730 617/271-3699.

MITRE Corp. (Hawaii office):

The Terrain Map Display Capability (TMDC) disc, 1983, is a one-sided disc with about 8,000 map images of the Pacific Command area, plus materials from the other MITRE disc of Fulda Gap. Contact: Richard Rhode, MITRE Corp., Staff CINCPAC J-21, PO Box 10, Camp H. M. Smith, HI 96861 808/488-0956.

Massachusetts Institute of Technology (MIT):

Both the Aspen Project and Spatial Data-Management System (SDMS) involved discs. Developed by the Machine Architecture Group at MIT, these discs (esp. the Aspen one) included surrogate travel imagery as well as maps and other spatial imagery. Both projects required use of a specialized equipment room that is no longer available; hence access to the discs is not possible in its original form. The Aspen project (for which four versions of a disc were produced) had street maps, the SDMS disc had a coordinated sequence of Boston area images such that one could zoom in on a satellite image until it matched the scale of a relatively small-scale map, which in turn one could zoom in on until it matched the scale of the next larger scale map, and so on. In total, the Machine Architecture Group has done about a dozen discs; it is unclear how many of those had maps on them. A recent disc entitled "Discursions" has sample images from several research projects (including some from Aspen) and is available for \$100. Contact: Machine Architecture Group, Massachusetts Institute of Technology, Cambridge, MA 02139 617/253-5981.

Online, Inc. (and Metamedia Systems, Inc.):

Online's STARS disc is in game format and is used to teach map and math skills (Army). The "game" involves finding Gen. Patton and obtaining his signature on an "important document." Contact: Jonathon Davis, Metamedia Systems, Inc., 20010 Century Blvd., Suite 101, Germantown, MD 20874 301/428-9160.

Perceptronics, Inc:

Perceptronics has been involved with several map discs and is in the process of producing several more. 1) The Vincent Elevators/Fulda Gap Disc, 1981, had about 14,000 map images on one side and nuclear aircraft training images on the other (filled). It was a prototype system for an Army distributed battlegame simulation system, funded by DARPA. Access was by UTM coordinates, and one could move around with the joystick and zoom in and out. About a 100 x 30-km area around the Fulda Gap (DMA 1:50,000) was included. About 50 copies were made, and copies are available. 2) The CATTs/MACE Disc, 1982, has about 42,000 images, about 15,000 for each of three areas: Fulda Gap, Sinai, and Fort Irwin, CA (National Training Center). The DMA 1:50,000 maps specially designed for video were used. (These "decluttered" maps were originally made for real-time camera in the CATTs system at Fort Leavenworth.) 200 copies of the disc were made and copies are available. Six levels of zoom were recorded and both horizontal and vertical sequences were done. Perceptronics did the visual graphics, software, and data base; BMD did a modification of the mathematical model for the simulation and did related software adaptation for the system. 3) The 5th Corps-1 disc, 1983, was for DARPA and the Microfix project. Both sides were essentially filled (108,000 images); most were maps but about 1800 were of 35-mm slides of key terrain features, avenues of approach, targets, etc. DARPA and FORSCOM funded the discs. UTM referencing, joystick movement, zoom, and overlay capabilities were included in the system. DMA 1:50,000, 1:250,000 and 1:500,000 maps were used plus a 1:1,000,000 non-DMA specially-designed map. 4) The 5th Corps-1/1983 disc is a followup to the previous one. Done in July 1983, it is essentially filled on both sides and has the slide images. It has horizontal sequences only and greater area coverage. 5) Central America, with several map types on it. 6) European Theater. 7) Northern Germany. 8) Southern Germany. 9) Five discs of North and South Korea (very northern region, North DMZ, DMZ, South DMZ, very southern region). 10) "Honicel" disc, with maps of Honduras, Nicaragua, and El Salvador at 1:50,000, 1:250,000, and 1:500,000 (in progress). 11) Six discs of SW Asia. (in progress). 12) Two or three CONUS discs for training (includes some imagery from Alaska and Hawaii as well as continental US) (in progress). 13) Two Caribbean discs (in progress). 14) Disc for Army's Distributed Command and Control System (DCCS), 9th ID, for the high technology test bed, Fort Lewis, with maps of Yakima, Fort Irwin, Fort Bliss, and photo and satellite images as

well (in progress). 15) Disc for Lockheed's navigational display unit for RPVs (in progress). 16) Disc with some maps as well as surrogate travel for a real estate agent in Beverly Hills (in progress). 17) Two discs for BDM for the European Theater (in progress). Contact Steven C. Johnston (or for acquisition, Robin Vivio), Perceptronics, 1911 N. Fort Meyer Drive, Suite 308, Arlington, VA 22209 703/525-0184.

RADC (Rome Air Development Center):

RADC is working solely with digital discs, not video discs. They are building two jukeboxes for 130 discs each for Digital Land Mass Systems. Currently they have only an RCA demo disc (digital), which is proprietary. Contact: Jack Petruzelli, RADC, Rome, NY 315/330-4581.

RCA:

The RCA Experimental Disc has topo maps of Germany, Iran, Burma, the DMZ in Korea, and Fort Leavenworth. It was produced using a vidicon camera. Contact: Gardner T. Burton, Manager, Design Engineering, RCA, Government Systems Division, Automated Systems, PO Box 588, Burlington, MA 01803 617/229-3480.

SRI International:

The SRI Map Legibility Study disc was produced in 1982 for experimental perception research for Lockheed. It contains 40 images. There are five levels of zoom for each of four original map scales (1:24,000, 1:50,000, 1:100,000, and 1:250,000) with each in black and white and in color ($5 \times 4 \times 2 = 40$). Maps are of the Hunter-Liggett area of California. Both the report and disc must be requested through Lockheed. Contacts: Dr. James Ketchel, SRI International, 333 Ravenswood Avenue, 301/68, Menlo Park, CA 94025 415/326-6200; Keyes Hudson, Lockheed Missiles and Space Co., Inc., PO Box 17100, Austin, TX 78760 512/448-6609.

US Military Academy, West Point, NY:

The West Point Geography and Computer Science Education Disc was produced in 1983/4 to support the educational mission of West Point. (The Academy's lab also has microfix equipment among its facilities.) Contact: CPT Vincent J. Mauro, Department of Geography and Computer Science, US Military Academy, West Point, NY 10996 914/938-2063 or 3691.

Video Disc Questionnaire
(Used as a guide in interviews)

1. Disc title (or brief identifying description):
2. Year of production:
3. Approximately how many frames contain:
 - map images?
 - air photo or remote sensing images?
 - other material?
4. What was the main purpose for creating the disc?
5. What company or agency: supervised/originated production of the disc?
 - did the tape in preparation for the disc (pre-mastering)?
 - did the mastering of the disc?
 - financed the disc project?
6. Is there an accompanying data base or other means of accessing the disc? (In other words, can you access the disc other than using the player control box and frame numbers.) If so, describe the data base briefly and indicate any georeferencing system by which you can access frames.
7. What maps were recorded on this disc (e.g., DMA 1:50,000 series USGS 1:24,000,...) and what is the geographical coverage?
8. With what equipment is the video disc used? (e.g., Pioneer player, Apple computer, Sony monitor,...; joystick, touch panel, bit pad,...)
9. How many copies of the disc were produced?
 - Are copies available to researchers for loan or purchase?
10. Who is the contact person for further information (name, address, phone)?
11. Other comments about the disc.

Appendix C

THE RELATIONSHIP BETWEEN MAP AREA PER FRAME AND MAP LEGIBILITY

In examining the experimental video-disc produced for ETL, USGS, WRSC, and NCEL it was readily noticeable that certain map images were very clear while others were quite unreadably blurred. It was also noticeable that the clear ones, those actually quite comfortable to look at, were at the closest zoom (camera closest to the map) while even at the next zoom level (about twice as wide in map space covered), deterioration was considerable. It turned out that the very clear image was of an area about 5 cm wide (i.e., 2 inches) on the map.

While the clarity of that size image is exciting, cartographically it is rather disappointing. Imagine trying to "use" a topographic map by looking through a blank panel with a 5 x 3.75 cm opening that remained stationary, while the map, pressed flat against the back of the opening, moved about. Much worse, imagine that you could never observe the actual movement of the map. Say the light illuminating the map automatically turned off during movement so the map simply "snapped" to the next position. That is almost exactly the condition imposed when trying to examine a map on the video disc.

But the point here is not whether the observation was exciting or disappointing or somewhere in between. The observation that the 5-cm areas were clear brings up such an important and such a basic design notion that it deserves considerable attention at a very early stage of work with putting maps on video discs. The best way of encapsulating the message of this essay is to say:

The key to capturing clear map images on video discs is the map area covered per frame. There is some small area in the vicinity of five cm in width that results in a clear image and the camera should be set to capture that much area regardless of the scale of the map materials being captured.

The point is undoubtedly exaggerated and oversimplified, but the notion is quite sound in theory. Let us take a look at what is behind it.

First of all, let us consider the matter of why one should not zoom in even closer than this 5-cm wide area. Surely if a video image 5 cm wide is clear, further blowups will also be clear (unless one can no longer focus the camera). Going closer, however, is a waste of disc frames because the material was already clear and even the 5-cm piece may be too small to contain "map information" because there is so little context; seeing a single symbol on the screen, for example, does not reveal any spatial information.

The matter of why not zoom in the other direction, even if the image is a bit blurry, so one can have many scales on the screen, is a bit more complex and is best left until we look at why the area to be covered on the map should be about 5 cm wide.

The 5 cm makes a lot of sense if one takes a look at the nature of the image on the monitor, the nature of the human eye, and the nature of the physical map. The figures involved in the discussion below are difficult to specify exactly, but still we will soon realize that map area covered is the key to clarity of image, and that with an ordinary (non-high resolution) monitor the ideal map per frame is fairly small.

The standard monitor (see Fink 1957) uses 525 scan lines, with some taken up in the "vertical blanking interval" (definition irrelevant here) or otherwise made irrelevant to what we see on the screen. Let us assume for the moment that 485 are forming the image we can see. Because the scan lines are not discretely energized spaces but rather are centers of energy distributions, the visual resolution of the screen is even less -- about 350 vertical by 320 horizontal lines (figures that are fuzzy averages to be sure and can vary from monitor to monitor). The resolution of these monitors was chosen by those setting standards because at average viewing distance the image looked sufficiently continuous that it made for comfortable viewing.

Now let us consider the human eye. Its resolving power is about one minute of arc although it seems pretty tolerant of images with resolution grosser than that. (Line printer images of human faces, for example, are easily recognized as such even when we can clearly see the discrete symbols.)

Finally, the map (let us assume a topographic map) as a physical object and regardless of its scale, is normally very high in "resolution" (fineness of markings) and at normal viewing distances, the resolving power of the eye is the limiting factor, not the resolution of the map. The normal map is designed for viewing at normal reading distance.

These three things (monitor resolution, eye resolving power, and map "resolution") come together in the following way: Let us assume we look at a map at a distance of 50 cm (about 20 inches) and that we are looking at a 50 cm map. Since the resolving power of the eye is about one minute of arc, there are approximately 3600 "eye pixels" (picture elements theoretically distinguishable by the eye) across the map. Assuming a resolution on the video monitor of about 335, how wide a section of the map could be put on the monitor without losing any resolution? The 335 pixels would take up 335/3600 of the 50 cm of the map width, which would be a width of 4.7 cm.

We could also take a very different approach to calculating the size of map area that can be captured. It seems that about nine lines

of resolution are needed per character to retain recognizability of type on a monitor. This seems to be well-known, as it came up in conversation with vendors and also appears in Wong and Yacoumelos (1971). Generally, it is type that deteriorates most noticeably as a camera moves back from a map, hence we can use size of type to estimate the size of capturable map area. Wong and Yacoumelos concluded that a 7.5 x 10 cm area could be captured, their figure based on a "readable" image rather than a sharp one.

Having established that a very small area "makes sense," now consider the problem of zooming away from the map. In looking at the "big picture" as opposed to the detail when using paper maps, we move our eyes back from the map, a process analogous to moving the camera back. With a topographic map, one might be 30-35 cm away when focusing on a very small area, and perhaps 55-60 cm when looking at the bigger picture, i.e., the whole map. But now let us see what happens when a video camera is moved away from a map until our whole map is included on a single frame.

Remember that a single frame has a resolution of about 335 elements across the image. The question, then, is not how far back from the map we should step until the map in our eye would subtend the same angle as it will on our monitor. The question is rather, how far back would we have to be from the paper map for it to take up 335 "eye pixels" across the width? Assuming the map is 50 cm wide (about topographic map size), we would have to step back to a viewing distance of more than 5 m! Needless to say, maps that are designed for ordinary viewing are not very useful at that distance and neither is the corresponding image on the screen.

One cannot argue that something like a full topo image should never be put on one disc frame. There may well be archival or reference reasons for putting it there, perhaps to give the user a visual cue for matching it with a paper map. For geographical information, however, it is useless.

In sum, pulling the camera back from the map has limited value. Large map spaces on a frame simulate readability (resolution) from extremely distant viewpoints.

Appendix D

OBSERVATIONS ABOUT TYPE ON VIDEO DISCS

In a short session with the video camera and monitor at Online, Inc., a look at approximately ninety typestyle sheets from the AM Varityper manual resulted in four tentative observations. Examination of the sheets was by the principal investigator only and simply involved choosing the type sizes that were barely readable and clearly readable when a sheet area 10 cm wide was being displayed on the screen.

(a) Most typestyles (Century, Universe,...) were clearly readable at approximately the same point size and none stood out as especially good or bad.

(b) Variations of a given style (condensed, regular, expanded; light, medium, bold; regular, italic) resulted in varying legibility. Condensed type deteriorated most noticeably; extended seemed to be more legible than regular, but only Eurostile and Eurostile Bold were observed in both regular and extended form.

(c) Bold lettering tends to be more legible than regular, but very bold lettering tends to fill in and lose legibility.

(d) There may be a tendency for Italic type to be clearly legible at slightly smaller size than regular type, but it may take a slightly larger size Italic type than regular to be barely readable, suggesting that the legibility criterion itself may affect conclusions about the relative effectiveness of different typestyles.

Appendix E

ILLUSTRATIONS

The following illustrations are provided as a supplement to this report. They show the major pieces of equipment used at ETL in its work with video discs and illustrate various levels of zoom that are available on the ETL/WRSC/USGS/NCEL disc. Overlay symbolism is also illustrated, as well as a variety of images encoded on the disc, and the processes involved in map disc design and production.



Figure 1. In this illustration an ETL employee is using the remote control box, which is pointed toward the video disc player, to access frames and display them on the monitor in the upper right. The small interface unit next to the player converts the standard television signal to the RGB signal needed for the type of monitor here. Under the monitor is a microcomputer and the keyboard is also clearly visible. The camera to the left of center in the foreground can be used to capture the contents of the screen. A video disc is visible in the left front corner of the desk.

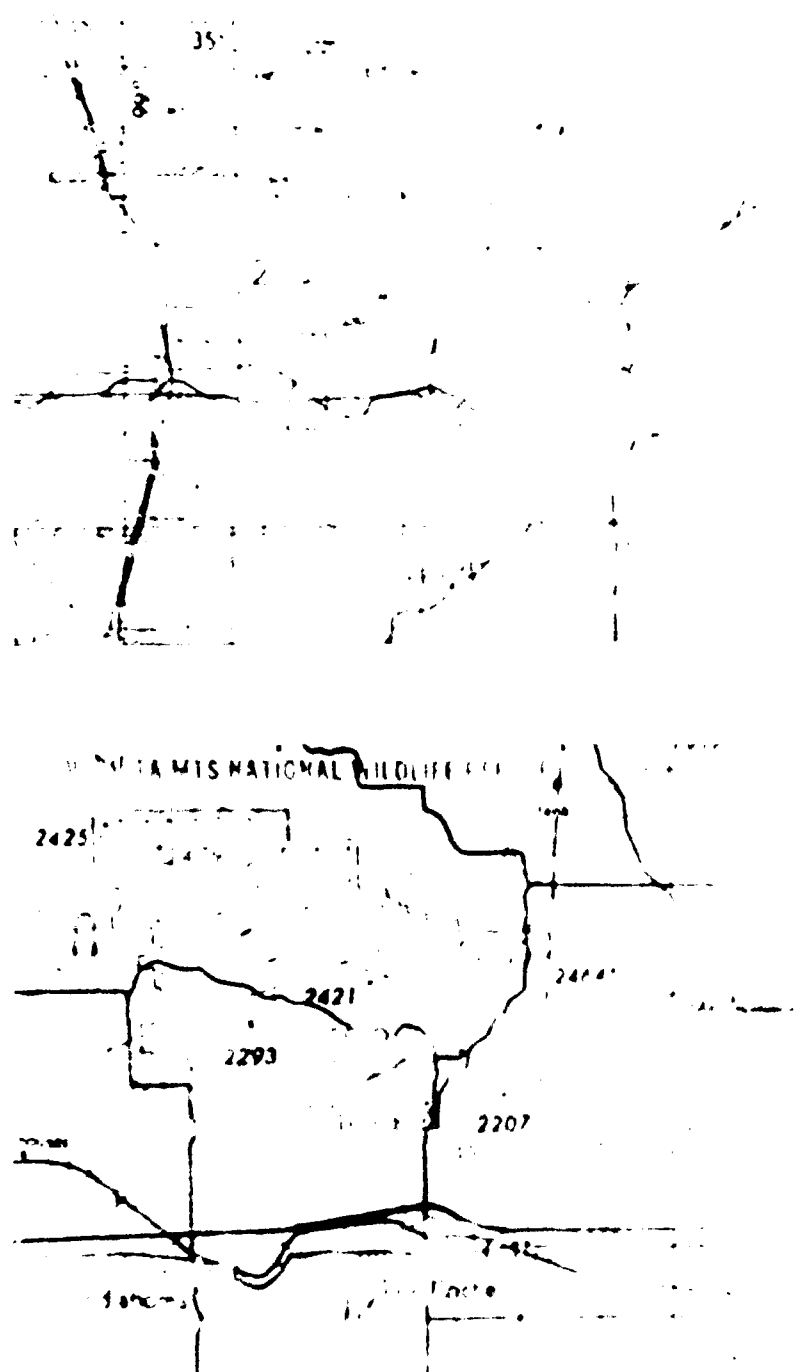


Figure 2. A pair of topographic map images illustrating two "zoom levels" available on the disc.

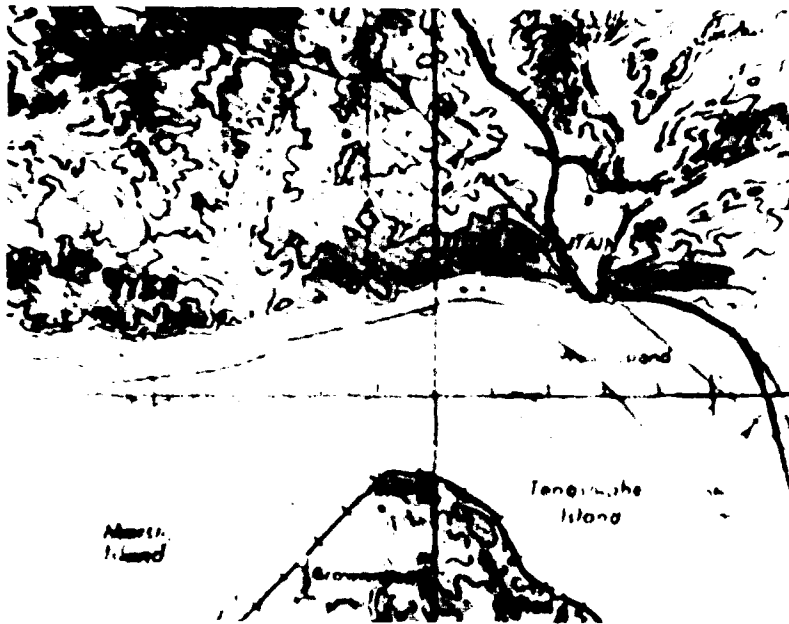


Figure 3. Another pair of images from a different map series, showing two zoom levels.

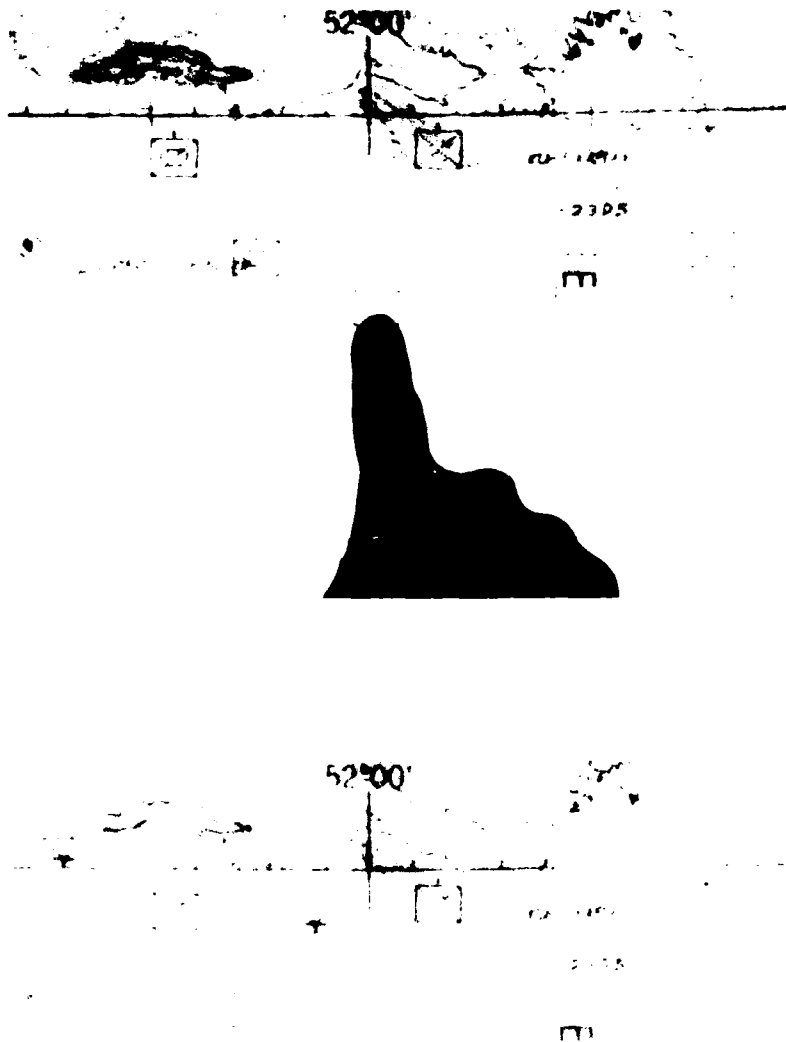


Figure 4. In the top illustration the user has touched the first symbol in the menu along the bottom of the screen and has then touched the displayed map where that symbol is to appear. The lower photo shows the map when the user has finished placing symbols.



Figure 5. Additional types of images appearing on the ETL/WRSC/NCEL disc. Top: Remote sensing image. Middle: USGS landuse/land cover map. Bottom: Three-dimensional terrain view generated from digital files and then captured on the disk as an NTSC frame.

INTERACTIVE CARTOGRAPHIC VIDEO DISC DESIGN AND PRODUCTION

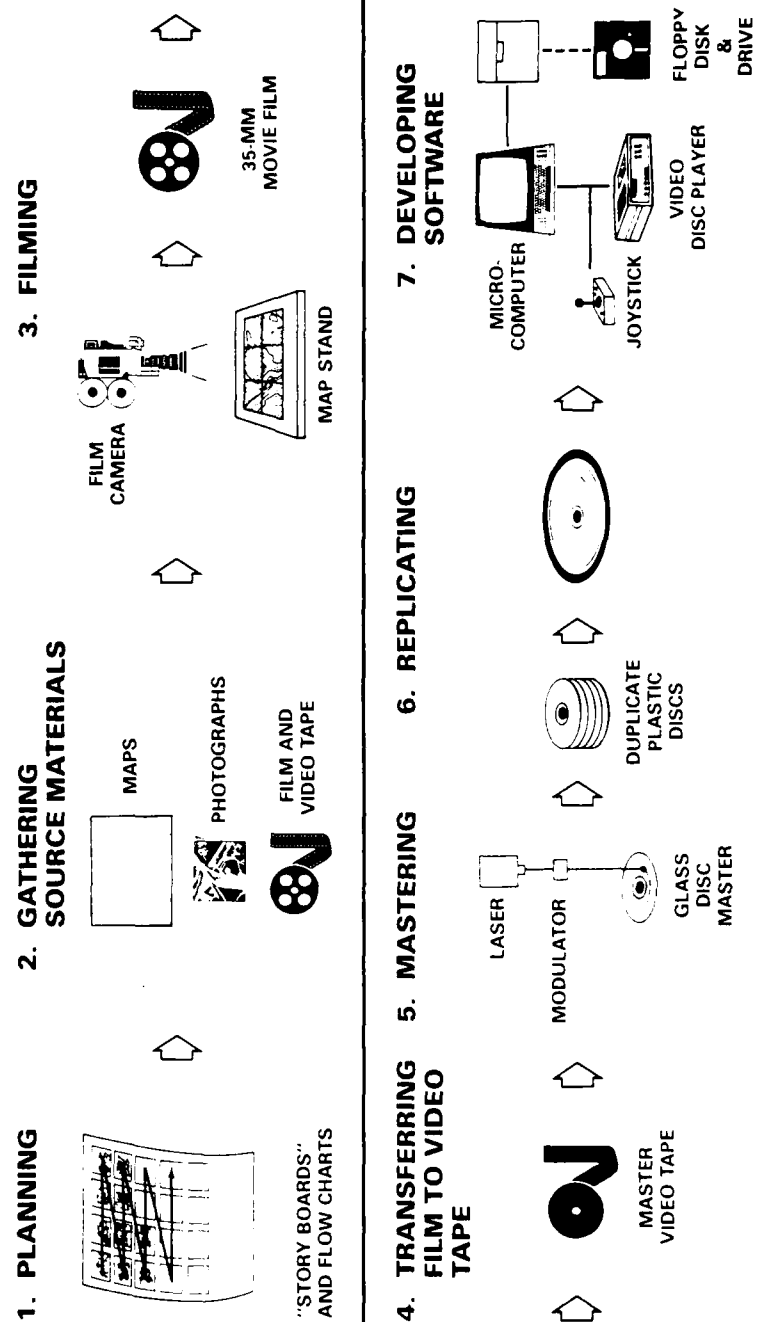


Figure 6. Schematic diagram of the stages in design and production of an interactive cartographic video disc.

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